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NOTES ON THE FAUNA OF THE ISLANDS OF FERNANDO DE NORONHA.

BY JOHN C. BRANNER.

FERNANDO DE NORONHA is a small group of islands in the south Atlantic, about 230 miles northeast of Cape St. Roque, and belonging to Brazil. It is only six miles long by about two wide. There is no important settlement upon it, and though it lies near the track of vessels plying between European ports and those lying south of the Cape, it is seldom visited by steamships and rarely by sailing vessels.

Very little is known of the natural history of this island. A very brief visit was made to it by Darwin in his famous voyage around the world, but the time he spent upon it—only a few hours—did not enable him to do much towards studying its natural history. In 1873 the Challenge Expedition landed here, but as the island is used for a penal settlement, the officer in charge of the colony would not give the party permission to make explorations. The few notes made by Mr. Darwin, and those of the Challenger party, furnish almost all the trustworthy information thus far published concerning it.

In 1876, when a member of the Imperial Geological Survey of Brazil, I visited Fernando de Noronha, and spent the months of July and August there, during which times the following notes were made upon its fauna:

The island is inhabited by a vast number of birds, most of

them sea-birds which flock and breed about the inaccessible crags and the small islands and rocks off the main island, and being but little disturbed by visitors, they are not timid, and may often be killed with clubs or caught with the hand.

One of the most interesting and beautiful birds on the island is the wig-tail, a white bird about the size of a pigeon, having two long flexible, streamer-like tail feathers.[1] These birds nest and roost mostly upon the lofty sides and about the summit of the great peak. At every hour of the day they may be seen hovering about this majestic rock like great white butterflies, or resting upon the little niches on its sides—white specks against the dark background. When seen at any considerable distance from their nests or roosting places they usually fly in pairs, side by side, each following the other's motions so exactly that one is at first inclined to think by some optical delusion there is but a single bird where two appear. They seldom fly in a straight line, but rise and fall and zigzag like butterflies.

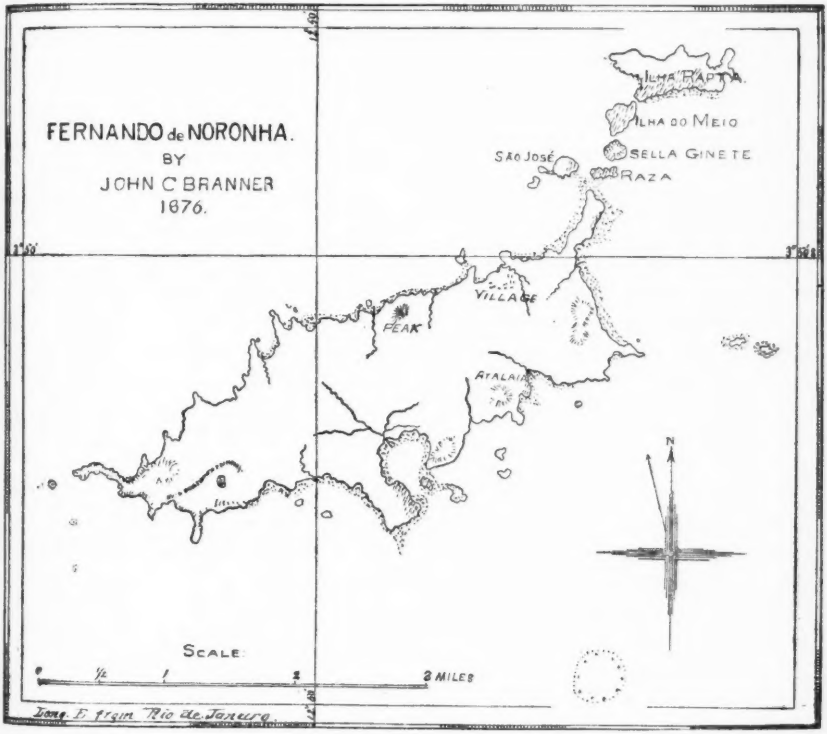
Rats and mice exist here in such numbers as, at times, to constitute a very serious pest and drawback to agriculture. It is recorded that during the occupancy of northern Brazil by the Dutch, about 1630, Fernando de Noronha was abandoned "by reason of the vast numbers of rats which consumed all the fruits of the earth."[2] As one walks through the fields or along the paths he constantly hears their rustling on all sides, and sees them darting here and there through the grass. A certain number of the convicts are assigned to the work of rat-killing, and each one is required to kill a specified number of rats every days. The number is incredibly large—somewhere in the hundreds—but I made no note of it, and dare not speak from memory. Cats and dogs have been imported in the hope that they might aid in the extermination of the plague, but though they usually kill them eagerly during a few days, they soon become so accustomed to their presence that they cease to pay the least attention to either rats or mice.

I made no notes upon the occurrence of rats and mice upon Ilha Raza and Sao José, and do not recall having seen them on

[1] The inhabitants call these birds by the very appropriate name of *rabo de junco*—reed tail.

[2] John Neuhoff in Pinkerton's Voyages, vol. xiv., p. 701.

those islands. Upon Ilha Rapta there are no rats, but mice are even much more abundant than on the main island. If they constitute a plague upon the main island, what shall be said of them here? It is simply impossible to realize, without having seen and experienced them, how mice can exist in such numbers. I spent a night on this island, the guest of the three convicts occupying



the place at the time. My hammock was suspended in the solitary grass-thatched hut, and at night I tried to sleep there, but with very poor success. The mice were all over the floor of earth, in

[1] This island is usually and erroneously called Rat Island, an error due probably to the fact that the *p* in *Rapta* is silent, and is supposed to mean rat, which it does not. *Rapta* is from the verb *raptar*, to steal, and Ilha Rapta translated into English would be Robbers' Island, or literally, Stolen Island.

the walls of thatch, in the roof, among the pots and pans—everywhere. No sooner did I lie down in my hammock than they made their way down the cords and into my bed. During the early part of the night I amused myself by allowing them to reach the middle of the taut hammock cords, when, by striking the cords a sharp blow, the vibrations would shoot them off into space. This ceased at length to be amusement, and when, late in the night, I occasionally fell asleep, it was only to be awakened in a few moments by the mice nibbling at my face or hands or feet, or by their falling upon me from the roof.

The occurrence of rats upon the main island and of mice only upon Ilha Rapta may possibly be explained by the mice having been imported to the smaller from the larger island. The geology of this group of islands, however, suggests another plausible explanation. Fernando de Noronha and the small islands lying about the main one are of igneous rocks, with the exception of some limited exposures of comparatively recent calcareous sandstones formed by the consolidation of sand dunes. These calcareous sandstones form all of Ilha Raza and Ilha do Meio, the southwest third of Ilha Rapta, and overlie a portion of Sao José and the extreme northeast point of the main island. It occurs also at the southeast base of Atalaia Grande, and in the Bahia de Sudoest, where it forms Ilha de Chapeo and the shore of the bay in places.

In all these localities the sandstone is cut away on its southeastern side, and an abrupt or overhanging face is exposed to the ocean's surf, while its upper surface stands at an elevation of from thirty to fifty feet and more above the water. On the landward side of the exposures on Ilha Rapta, Sao José and the main island, these sandstone beds thin away to the west. These facts, and others which need not be mentioned here, go to show that the southeastern coast of these islands formerly extended much farther in that direction, and that the calcareous sands, of which these rocks are formed, were blown inland from the beach which once existed in that direction. The ocean, however, has gradually encroached upon the island, and especially from the east, until what was formerly one island has been separated into six, namely, Sao José, Sella Ginete, Ilhas do Meio, Rapta, Raza, and the main island.

The mice which are so abundant upon both islands now may

have been cut off from the main island and left upon Ilha Rapta when this separation took place. Whether they would survive upon the other islands, Ilha do Meio, Ilha Raza, etc., would depend entirely upon whether the conditions upon them for survival were favorable or otherwise, and their existence or non-existence at intermediate points would have but little bearing upon the question. It may be asked, in case this theory is correct, why we find no rats upon Ilha Rapta. This is possibly to be attributed to their having been entirely exterminated by the convicts.

Ilha Rapta is, in a sense, one of the institutions of the penal settlement. It has an area of less than a square mile, no wood, though it is said to have been wooded formerly, but little potable water, and, compared with the main island, it is very low. The soil is extremely fertile, and excellent sweet potatoes grow wild over a large part of it, while the waters about its shores swarm with edible fish and enormous sharks. When, at the time of my visit, and prior thereto, a prisoner upon the main island became particularly unmanageable, he was banished to Ilha Rapta, which was regarded as a sort of *insanctum insanctorum*, where he was left to his own devices for subsistence.

I learned from the commandant that formerly large numbers of convicts were banished to Ilha Rapta at the same time. Now it was generally understood when I was upon Fernando that rats were not uncommonly eaten by the convicts on the main island, and as those sent to Ilha Rapta were left to do as they saw fit, they were often reduced to great straits for food, and it does not seem improbable that they ate rats, if rats ever existed there. Then, too, when efforts were made to raise crops here, the rats, had they existed in such numbers as upon the main island, would simply have rendered such crops impossible. The area of the island is so small, and the places in which rats could hide so few, that their extermination would not be an impossible or even a very difficult matter.

I trust that the novelty of it will be sufficient apology for a short digression here to describe the method employed by the convicts on Ilha Rapta to catch fish. A hook attached to a line about 150 feet long, baited with a fresh sardine or the white skin of some other fish, is thrown out into the water and quickly drawn ashore.

The method is thus essentially trolling without a boat or spoon. One end of the line is tied to the fisherman's body, the line coiled and held in the left hand, while the baited hook, weighted with a bit of lead, is whirled rapidly above the head with the right hand, until the centrifugal force becomes strong enough to carry the line out to its full length when skilfully thrown. It is then allowed to escape, and the lead, carrying the line with it, shoots out over the water and drops. The line is then hauled in as rapidly as possible, and this rapid hauling in generally produces a whirling of the bait at which the fish strike. There is "many a slip," though, between hooking a fish and landing it; not that they are particularly game, but because the sharks are usually fishing at the same time and place. Not more than half the fishes I saw hooked here were landed entire; sometimes only half a one was hauled in, at others only a head, and sometimes the hook and part of the line were also missing.

Standing upon one of the overhanging rocks at the western end of the island I have looked down into the sea when it was comparatively smooth and seen hundreds of enormous sharks in the water, gliding over and about each other in their search for food.

Perhaps the most interesting vertebrate found on Fernando is a species of lizard—*Mabina punctatas*. The cultivation of almost all the tillable land on the island has had the tendency to drive these lizards into the rocky corners and uncultivated places, where they exist in such great numbers as to cause one to wonder how so many of them manage to live on so small an island. As they are but little disturbed, and have no natural enemies here, they are not very timid. Walking over the open, rocky places where there is no vegetation, one may see the lizards withdrawing down the sides of the rock fragments, apparently with much reluctance, at a distance of from three to six feet ahead of him. If he turn and look behind he will find them rapidly closing up the space yielded him for a passage. While seated upon the bare rocks I have often observed these little animals watching me, apparently with as much curiosity as I watched them, turning their heads from side to side as if in an effort to be wise. If I kept quiet for a few minutes they would creep up to me and finally upon me; if I moved, they

ran down the faces of the rocks, and turning, stuck their heads above the edges to watch me. I caught a great many of them [1] by keeping quiet until they came within easy reach and then snatched them. They bite freely, but their teeth are too short and weak to inflict a severe wound. Upon one occasion when climbing with my photographic apparatus up a steep bluff, where great care and attention had to be given to every step and motion, my movements were not sufficiently rapid and decided to keep the lizards off my person, and as neither of my hands was free, they became offensively familiar. Several of them crawled leisurely over me examining my clothing and my person, and one even got up the leg of my trousers, and for nearly an hour crept around and around my waist just below the band of my trousers.

I was told by the inhabitants that there was another kind of a lizard on the island which had two tails. I found, however, that the so-called forked-tailed lizard was the same as the above mentioned one. The tail of this species is long and slender, and is so easily broken that it was quite difficult to catch one without breaking off a portion of its tail. If the piece broken does not fall off entirely, the break may heal over sufficiently to hold it securely, while the growing out of the new tail gives the lizard a forked or double one. I have seen it stated, I believe in the Challenger reports, that this species has never been found elsewhere in the world than upon Fernando de Noronha, and that the species to which it is most nearly related occurs in Demerara.

I saw no snakes upon the island, and the old residents say there are none, save what is known in Brazil as the *cobra cega* (blind snake) or *cobra de duas cabeças* (double-headed snake). I found one specimen of this. It is a species of Amphisbæna.

Several insects are found, the most abundant of which is a species of wasp, which does considerable damage to grapes, and by building nests in the cajú trees renders itself very obnoxious. Spiders are also very abundant. A few beetles and butterflies were taken, but the material was turned over to Mr. Herbert H. Smith, and I am unable to say what they are. All kinds of domestic

[1] These specimens, like all the other material collected upon this island, was deposited in the Museu Nacional in Rio de Janeiro. As far as I know, none of it has ever been worked up.

animals have been introduced upon the island, but they do not enter into the biologic question to which I would call attention.

It does not seem improbable that the original flora and fauna of Fernando were introduced here at the same time and from the same source. I regret that I made no notes of value upon the flora of the island, but I may call attention to this peculiarity of it: its large trees produce light wood, that is, wood that will float in the water. The flora of the Brazilian mainland is noticeable for the predominance of very heavy timber, most of which, even when well seasoned, is of too high specific gravity to float in salt water. One of the large trees of Fernando is the *Ficus noronhae*, a species first described from this island. Another is the *burra*, a species of laurel yielding a poisonous juice. I believe I have seen the laurel in the highlands of the province of Minas Geraes, but I am not quite positive about the identity.

The question naturally arises: Where did the animals inhabiting this island come from originally, and how did they get to Fernando de Noronha?

The first answer which suggests itself is that they have been imported by man's agency since the place was discovered. Very fortunately we have valuable documentary evidence upon this subject. The following is a translation of the oldest document in existence referring to the island of Fernando de Noronha:—

". . . . In view of the services which Fernam de Noronha, cavalier of our house, has rendered, and which we shall expect of him hereafter, and desiring to show him grace and mercy, we are pleased to bestow upon him henceforth for all the days of his life, and on his eldest legitimate son surviving at the time of his death, our island of Sam Joham which he has just lately discovered fifty leagues over the sea from our land of the holy cross."[1]

This is a portion of the patent issued by the King of Portugal, January 24th, 1504, at "Lixboa," and recorded in the royal archives of Portugal.[2] Now "Sam Joham," or in modern Portuguese,

[1] The original name given Brazil by Cabral was *Vera Cruz*. It was generally known, however, as the *Terra da Santa Cruz* until about the middle of the sixteenth century when the name Brazil was generally adopted.

[2] Real Archivo, Bk. 37, Chanc. D. Joao III., Fol. 152. (Dairio de Pero Lopes, p. 71–2.)

Sao Joao, was the original name of the island, and after this patent it appears to have been known by the name of its owner, Fernam, or Fernando, de Noronha.

From this document, and others relating to the fleet in which Fernando de Noronha sailed, it is believed that the island was discovered on the 24th of June (St. John's Day), 1503, and that it was called the island of "Sam Joham," or St. John, in accordance with the usage of the times, which was to name places after the saints upon whose days the discoveries were made.

Americus Vespucius claims to have visited this island on his fourth voyage,[1] six weeks after its discovery by Fernando de Noronha. I am aware that historians question whether this voyage was ever really made by Americus Vespucius, but judging from the description given by him it must be confessed that if that navigator did not himself see this island, he obtained his information concerning it from some one who did visit it, and for our purposes this serves the same end. If his informant was a member of Fernando de Noronha's party, it is only the more valuable in the present connection. The description given by Americus Vespucius is brief, but it is the earliest one published, and therefore the most important for the present discussion. According to this account he touched here August 10th, 1503, and he writes:—

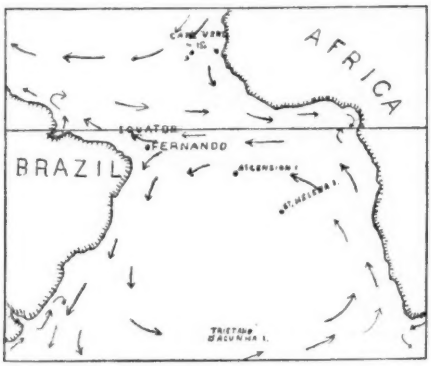
"..... Which island we found inhabited, and it contained plenty of trees, and so many birds, both marine and land, that they were without number, and they were so tame that they allowed themselves to be caught with the hand; and we caught so many that we loaded a boat with them; and we saw no other animals except very big rats and lizards with two tails, and some snakes."

As the introduction of birds, whether marine or land, upon an island 230 miles from a large continent, cannot be regarded as difficult or impossible, the presence of birds upon Fernando may be passed by as of no particular importance. The interest in this case centres upon the "big rats and lizards with two tails and some snakes" mentioned by Americus Vespucius. As the island was discovered but six weeks prior to the reported visit of this

[1] Stanislau Canovai's Viaggi d'Amerigo Vespucci, Ed. 1817, p. 110, *et seq.*

navigator, it is clearly impossible that these animals, if imported by the discoverer, could have multiplied in so short a time sufficiently to have attracted attention. Nothing is said of the mice, and it may therefore be that these are or are not aboriginal inhabitants of the island. But the rats are here, and the lizards with two tails, the only ones likely to attract the attention are here, and the Amphisbæna is here, an animal bearing such a resemblance to a snake that by most people it is called a snake, even to this day.

Where did these animals come from? Rats are world-wide in their distribution; the species of lizard found here has never been found elsewhere; Amphisbæna is abundant in Brazil, and in Africa, and one genus (Blanus) is found about the Mediterranean. If we suppose that they migrated from the Brazilian mainland, and that the *Euprepes* does occur, but has not yet been found there, a question as to method arises. Now as the ocean currents do not,



at any time of the year, set eastward, northeastward or southeastward from the eastern part of the South American continent in the direction of the island of Fernando de Noronha, the chance of such animals being carried from the Brazilian mainland are extremely small. The island receives the currents from the southwestern coast of Africa, as is shown in the accompanying cut; indeed the west flowing south equatorial current divides just about here, the current striking the island and flowing either to the northwest or to the southwest along the Brazilian mainland, according to the time of the year and the direction of the trade winds. The wind

charts usually represent the prevailing winds in this region as coming from the southeast. During the months of June, July, August, and September, they do come from that direction approximately, but during the remainder of the year they are usually from the northeast.[1] The ocean currents shift slightly with these prevailing winds, so that when the winds from the northeast have prevailed for some time, the main body of the south equatorial current seems to be carried further south. Such changes throw upon Fernando at one time the currents from southwest Africa, and at others probably some of the counter-currents from the North Atlantic or from the Gulf of Guinea.

Dr. Alfred R. Wallace, with whom the writer has spoken in regard to this question, suggests that these animals may have been introduced upon the floating trunks of trees from Africa. If we admit that such animals could endure so long an ocean voyage, the explanation satisfies the demands of the case as far as we are acquainted with them.

The long existence of navigation as a science prior to the discovery of America, suggests that rats might have been carried here upon a wrecked vessel. But even admitting that the Amphisbæna and the lizard might have come from some part of the Mediterranean, the chances of such animals finding their way upon board vessels are so extremely small that this hypothesis seems to have but little or no value.

It has been suggested also that the islands of Fernando may have been joined to the Brazilian mainland at one time, and that by the cutting away of the isthmus joining the two, the island was thus left with the fauna found by its discoverers. The form of the ocean's bottom between the mainland and the island puts this hypothesis out of question. It was formerly supposed that Fernando had once been the northeastern point of Brazil, but the deep-sea soundings by the Challenger expedition show that this is not true, and that Fernando is separated from the mainland by a trough more than 12,000 feet deep. In the light of these facts the question remains: where did these animals come from, and how did they get here?

[1] During my stay upon this island, in the months of July and August, the wind varied but little from due east, being at times from the E. N. E., and at others from the E. S. E.

VALUES IN CLASSIFICATION OF THE STAGES OF GROWTH AND DECLINE, WITH PROPOSITIONS FOR A NEW NOMENCLATURE.[1]

BY ALPHEUS HYATT.

IN accord with views brought to the notice of the society in 1884, under the title of the "Larval Theory of the Origin of Tissue,"[2] an abstract of which was subsequently printed in *Amer. Journ. Sci.* May 31, 1886, we divide the animal kingdom into three comprehensive divisions: (1) PROTOZOA, unicellular animals, which propagate by means of asexual (autotemnic) fission and by spores, and build up colonies, but always remain typically unicellular. (2) MESOZOA, multicellular colonies, but composed of only one layer of cells, so closely connected, that they may be called a primitive tissue, and having more or less spherical forms.[3] They propagate by means of ova, spermatozoa, and by autotemnic fission,[4] and have an aula or common cavity, but no specialized digestive cavity or archenteron. (3) METAZOA, complexes of multicellular colonies, in which growth by sexual union, and resulting fission of the ovum, forms three primitive tissue layers and builds up a body in which an archenteron is always developed. They propagate always by means of ova and spermatozoa, autotemnic fission occurring only, if at all, during the earliest stages of the ovum. Holoblastic ova may be regarded as the more primitive or generalized forms to which all

[1] Abstract of a paper read at the meeting of the Bost. Soc. Nat. Hist., Nov. 16, 1887. Vol. xxiii.

[2] Proc. Bost. Soc. Nat. Hist., vol. xxiii., 1884, p. 45.

[3] See Butschli's remark that the closely appressed hexagonal cells of the envelope are connected with each other by threads of propaplasm. Bronn. Thierreichs, vol. i. Protoz., p. 775.

[4] The best summary of all observations is in the work just quoted, where Butschli calls the sexual cells ova and spermatophora, but alludes to the cells developing by autotemnic fission as Parthenogonidia. They are by his own descriptions and those of others, ova, which differ from sexualized ova only in their ability to develop through autotemni fission.

other forms of ova having more or less specialized and concentrated modes of development may be referred as derivatives. The stages of holoblastic ova may be in a general way classified as follows, to accord with that given above for the Animal Kingdom :—

(1) The ovum or Monoplast (Lankester); (2) the first stage of segmentation, which normally results in the production of two cells in the same place originated by vertical fission, the Monoplacula; (3) the second stage of segmentation in which two layers arise, the Diploplacula. The first two stages alone seem to have parallel or representative adult forms among Protozoa. The differentiation into esoteric, primitive ectoblast, and enteric, primitive endoblast cells takes place in the Diploplacula, and the morphological equivalent of this stage of the ovum, having an upper layer of differentiated feeding cells, has not yet been found among the adults of the Protozoa; though, if this is correct, such a discovery may be reasonably anticipated. We have proposed to classify these stages under the name of Protembryo.

(4) The Blastula is in aspect and general characteristics the morphological equivalent of the adults of the genera Volvox and Eudorina, the types of the Mesozoa or Blastrea. The latter are animals in which growth remained permanently arrested at the single-layered, spherical stage in the evolution of tissue-building forms. We have proposed to classify these stages under the name of Mesembryo.

(5) The Gastrula can be compared, as has been done by Hæckel, with the lower Porifera (Ascones), but these have three layers like the lowest Hydrozoa, in which a three-layered gastrula-like stage has been permanently preserved.[1] The proper name for these stages would therefore be Metembryo, in allusion to the fact that the ovum at this stage is probably essentially a Metazoon.

(6) The first and simpler Planula stages, though often character-

[1] The true two-layered Gastrea type of Hæckel has, therefore, not been discovered. Doubtless, some such animals bringing the gap in the line of graded modifications between three-layered Ascones and single-layered Volvox will yet make their appearance, but we cannot consider any of the animals heretofore described as filling this gap to be entitled to such a position. They have all proved to be either three-layered, or else to belong to the true Mesozoa or Protozoa. See also for remarks on the prevalence of the three layers even in the gastrula, Metschnikoff, "Ueber gastrula einiger Metazoen" Zeitz. Wissen. Zool., V. 27, 1882, p. 305.

istic of the larger divisions of the Animal Kingdom, would not, if arrested at this period, be recognized as belonging to the same groups as their existing adults. They do not possess, as a rule, the essential diagnostic characters of the larger divisions to which they belong, and we propose to call them Neoembryos. Examples: the Cinctoplanula is not a sponge, the Planula of the Coelenterata is not a Cœlenterate, nor the Pluteus an Echinoderm, nor the Trochosphere a Mollusc, nor the Pilidium a Nemertean worm, nor the earliest planula-like ciliated stages of Amphioxus a Vertebrate. Neoembryos are, as pointed out by Semper,[1] Lankester[2] and Balfour,[3] so similar, that they may be considered as indicating a common ancestor for the entire Animal Kingdom.

(7) The latest of the more specialized planula-like stages are either directly transformed into, or else give rise to other forms in which the characters of the larger subdivisions or types of the Animal Kingdom begin to appear, at least so far as essential characters are concerned. Examples: the Ascula and Ampullinula are true sponges, the Actinula is a Hydrozoon, the Gulinula is an Actinozoon, the Veliger is a Mollusc, the internal worm-like form arising in Pilidium is a true Nemertean, the formation of the notochord in Amphioxus makes the planula-like embryo into a vertebrate animal. They have the essential characters of the larger subdivisions, though it is equally true, that embryos in this stage of development are very remote, in some cases, from the adults of any normal forms. We do not, therefore, misinterpret these relations by naming the embryo in these last stages the Typembryo. This term can be applied to the Nauplius of Crustacea, and the Echinula[4] of Echinodermata, as well as to those above noted.

[1] Semper, Stammsver, Wirbel. und Wirbello., Arbeit. Zoolog. Zootom Inst., V. ii., p. 59, and V. iii., p. 384. This distinguished author states in Volume iii., that his "Trochosphaera" is identical with the "ungegliderte Urnierenthier" which in his first table in Volume ii., appeared as the common ancestor of the higher animals, *i.e.*, of all animals except Echinodermata and Cœlenterata.

[2] Lankester traced the Mollusca, Annelida, Rotifera and Echinodermata to what he calls the Architroch, a common form taken from some what earlier stages of the Planula than those selected by Semper for his Trochosphaera. Embryol. and Classif. Journ. Micros. Sci., vol. xvii., 1877, p. 423.

[3] Balfour, Comp. Embryol., vol. ii., p. 311.

[4] Alexander Agassiz, Address, Am. Ass. Adv. Sci., V. 29, 1880, p. 410, shows that there is a stage of the embryo common to all orders of living

Typembryos serve to connect the earlier stages of the Neoembryos with the true larval stages which succeeded the former. Balfour and other embryologists have used the term "larva" for free neoembryos and typembryos. This term should be confined to the designation of stages of growth which are immediately continuous with later stages and parallel, or referable in their origin to the adults of allied, existing, or fossil forms, which are not so remote as those from which the embryonic stages were derived.

The application of such principles to the study of the younger stages of fossil Cephalopoda is productive of what seem to be satisfactory results. The protoconch of Owen is, according to this nomenclature, the shell of the univalve veliger of the Cephalous Mollusca, and a true typembryo which, though eminently characteristic of that group, has no exact morphological equivalent among adults of normal forms whether recent or fossil.

The protoconch in fossil Nautiloidea is represented by a withered-looking lump sticking to the apex of the conch in a very few exceptionally perfect specimens. The very general absence of this lump and the presence of a scar left by its removal on the apex of the conch, and the wrinkled, shrunken aspect of the lump when preserved, indicate the protoconch to have had a horny texture in this order. This typembryo shell must have existed among Nautiloids with an almost unchanged aspect from the earliest Cambrian (Lower Silurian) horizon until the present day, and its adult equivalent probably existed before its appearance in Cephalopoda or in the equally ancient and allied group of the Pteropoda, which also had similar protoconchs.

The true larval, or as they are here named, Silphologic[1] stages, began with the formation of what Owen has appropriately called the apex of the conch or true shell. Among Nautiloids this was a short living chamber occupied by the body of the animal, but having no

Echinodermata. This stage, however, was not named in the address above quoted, which was intended as preliminary to an illustrated essay on the same subject, and Mr. Agassiz has supplied that omission in the following note, which I quote from a letter to me. "I intended sometime when revising my 'Address on Palæontological and Embryological, Development,' to call the earliest common stage of echinoderm embryos 'Echinula' for convenience in making comparisons.—A. Agassiz."

[1] *Σίλφη*, a grub.

siphon or septum. It was completed by the deposition of the apical plate, which sealed up the aperture of the protoconch thus closing the opening and cutting off communication between the two interiors.

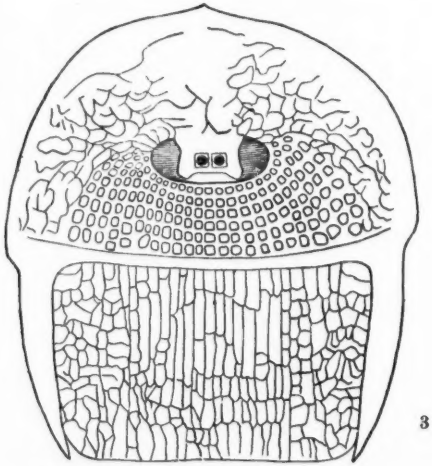
This stage can therefore be named the asiphonula or siphonless larva. The apex of this conch was rounded, being built out in concentric circles from the contracted aperture of the protoconch, probably before this was plugged up by the deposition of the apical plate. The asiphonula was not a Cephalopod, since it had no central siphon, nor even a septum. It may have resembled more or less closely the adults of some of the ancient Pteropoda. Von Jhering has thought, that the characteristics of the early stages of Ammonoids justified a comparison between them and forms of Pteropoda having similar protoconchs. This was our own position also, but we now see, that the asiphonula was not necessarily a wholly pteropod-like animal. It may have retained many of the veliger's characteristics, and may have more or less resembled a generalized type to which a Scaphopod is the nearest living approximation. Prof. W. K. Brooks' opinion, that the Scaphopods are such a generalized type and that the veliger has characters which can be compared with those of the adult of Dentalium ought at any rate to be considered here.

It is not at all improbable, that the Pteropoda may never have served as radicals for the Nautiloids or Ammonoids, but the latter may have sprung directly from the ancient Scaphopoda.

The cicatrix naturally suggests comparison with the posterior opening in the shell of Dentalium, but if our view is the true one, and it represents the aperture of a protoconch, no such comparison can be made. The development of the conch in Dentalium is, according to Lacaze Duthier's researches, directly continuous with that of the protoconch, and the posterior opening is the result of the peculiar mode of growth of a primitive plate of shell which is never closed up. The shell, in other words, is a *periconch* growing around the body in the veliger and finally coalescing to form a tube open at both ends.

The second larval stage in Nautiloidea was composed of a living chamber closed apically and completed by a single septum, which had a cæcal prolongation reaching across the first air chamber and

[1] Proc. Bost. Soc. Nat. Hist., Aff. Moll. and Molluscoid., V. 18, 1876.



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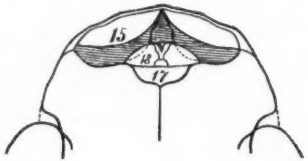

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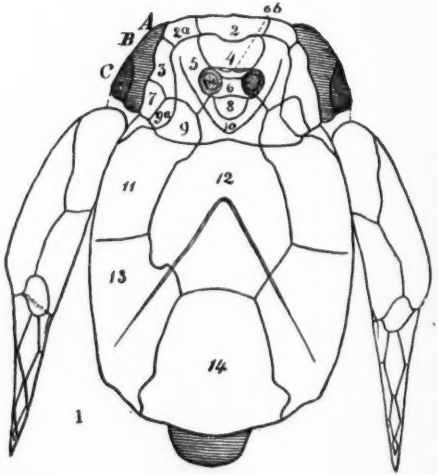

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Fig. 1. Shell of *Bothriolepis canadensis* Whiteaves, from above. (From Whiteaves.)
Fig. 2. Anterior part of same from above. (From Whiteaves.)
Fig. 3. Skull of *Mycterops ordinatus* Cope, from below, $\frac{2}{3}$ natural size.

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resting upon the inner side of the scar. It is proposed to call this stage the Cæcosiphonula, since it is undoubtedly the primitive stage of that organ. The cæcosiphonula may indicate the former existence of an ancestral form having a central axis composed of similar closed funnels or cæcal pouches.[1]

The third Silphologic stage in Nautiloids was completed by a septum (the second in the apical part of the shell) having an open funnel extending apically and joined to a loose textured siphonal wall which reached down into and lined the cæcum, thus forming a secondary closed tube. In accordance with the structure this has been named the Macrosiphonula.

The protoconch was present in Ammonoids and also in Belemnoids, but in both of these orders it was calcareous. The tendency to form a calcareous shell, which first appeared in the apex of the conch of the asiphonula in Nautiloids, became by concentration of development inherited earlier in the Ammonoids and Belemnoids in the veliger stage, thus transforming what would otherwise have been a horny shell into a calcareous one. The protoconch was, however, not otherwise changed in external aspect and retained the usual egg-like shape of the univalve veligers of the Cephalophora. As in the protoconchs of other similar veligers of Gasteropoda, etc., and as a result of calcification, the protoconch became fused with the apex of the conch more intimately than in Nautiloids. In other words the asiphonula, after transmitting a portion of its characteristics to the typembryos of the Ammonoids and Belemnoids, disappeared, having been replaced by the Cæcosiphonula. The septum of the cæcosiphonula was consequently also inherited earlier, and became a functional substitute of the apical plate serving to close the aperture of the protoconch, and its cæcum extended into the upper part of the otherwise empty protoconch, in place of occupying the first air chamber as in Nautiloids. This is a remarkable example of the law of concentration, but by no means exceptional. The fourth larval stage of the Nautiloids was completed by the building of the third septum. This septum had a long funnel and attached porous wall, but the wall formed a true siphonal tube opening apically into the next section, the macrosiphon. This

[1] See also similar remarks by Whitfield, Bull. Amer. Mus. New York, No. 1, and Embryol. Ceph. by the author, Bull. Mus. Comp. Zool., V. 3, No. 5, p. 100.

was the beginning of the small siphon and can be appropriately termed the Microsiphonula. The microsiphonula was the typical stage of nearly all the known genera of Nautiloids, beginning with the Orthoceratites of the Cambrian and found at the present time in Nautilus, and also in all Ammonoids and Belemnoids without exception.

Fortunately the genesis of both macrosiphonula and microsiphonula can be traced in the adult forms and silphologic stages of well-known fossils. The Crytocerina had a siphon which was macrosiphonulate probably even in the adult stage, since it increases in diameter throughout life. Piloceras had a huge siphon hardly at all contracted in the adults of some species, but considerably lessened in diameter during the same stage in others. Endoceras had also a large siphon always more or less contracted in the silphologic or later stages. The uncontracted macrosiphonula occupied in this genus a number of air chambers varying according to the species, from a few to six or more. This was evidently due to the earlier inheritance or concentration of the tendency to decrease the diameter of the siphon first manifested in the adults of Piloceras. Sannionites was a genus in which the siphon was smaller than in Endoceras, and probably, though this is not yet ascertained, inherited the tendency to microsiphonulation at the first septum at an earlier age than in Endoceras. None of these forms, however, attained a true microsiphon, since even Sannionites had the siphon filled by endocones and in the centre an endosiphon. These organs entirely disappeared in true microsiphonulate forms and, in fact, could have existed only within a large macrosiphon.

Nevertheless this tendency to decrease the size of the siphon resulted in the formation of a definite constriction. This constriction was inherited at earlier and earlier stages after its origin in the siphon of Piloceras, until it became constant perhaps in Sannionites and certainly in the Orthoceratidæ. The constriction marked the line between the larger and smaller siphon in the macrosiphonulate forms, and, in becoming constant through concentration, it became invariably fixed behind the first septum between the cæcosiphonula and the smaller siphon. This smaller siphon, though still a macrosiphon in structure, as explained above, even in

Sannionites, was undoubtedly transitional to the true microsiphons of the Orthoceratidæ.

The cæcosiphonula was in all Orthoceratites, which are otherwise similar to Endoceras, confined by concentration of development to the first air chamber, and a true microsiphonula appeared at an early stage as an open narrow tube. This was similar to the siphon of the vast majority of all succeeding forms of both Nautiloids and Ammonoids. According to the classification here advocated, the stages preceding the microsiphonula, viz.: the asiphonula, cæcosiphonula and macrosiphonula, became silphologic stages in all the groups of Cephalopoda descending from the radical Endoceratidæ. Microsiphonulation became silphologic in the Orthoceratidæ, and the smooth shell which they evolved was subsequently inherited among Nautiloids, Ammonoids and Belemnoids during the younger stages in all the species of these orders. Other forms, with depressed and involved whorls, were introduced in the main stock of radicals among Goniatitinæ, and were modifications of the smooth cylinder of the simpler Orthoceratidæ with its microsiphon. These in turn became the proximal radicals of derivative groups. Thus the Anarcestes[1] among Goniatitinæ became the radicals of the Ammonoidea, and the smooth silphologic stages of all Ammonoids after the expiration of the Devonian were like the adults of these lowest forms of Goniatitinæ. This later acquired silphologic stage has therefore been styled the Goniatitinula.

It has also been found, that in tracing the descent of forms within smaller groups, sub-orders, families, and genera, it is practicable, as in the case of the family of Endoceratidæ, to prove that characteristics usually appear first in adult stages and are then inherited at earlier and earlier stages in successive species of the same stock, whether they occur on the same horizon, or in different horizons. The adolescent or Nealogic[2] stages are of as great importance for tracing the genealogy of small groups as are the silphologic characters in larger groups. Thus one can speak in definite terms of the relations of the nealogic stages, and their meaning and importance in tracing the genealogy of families and genera,

[1] Gen. Ceph. Proc. Bost. Soc. Nat. Hist., V. 22, 1880, p. 305.

[2] *Νεαλής*, youthfulness.

without danger of confusing them with the characters of any of the silphologic stages.

After the silphologic and nealogic stages have been disposed of there still remains the adult period, which is equally important in genealogical investigations, since it enables the observer to study the origin of many characters, which afterwards become silphologic and nealogic in descendent forms.

It is not uncommonly assumed, that adaptive characters appearing in embryos and larvæ are apt to be transient and have but little effect on the subsequent history of the early stage in the same group; also, that such characters have appeared just as readily in the larvæ as in adults. Up to the present time this has not been found to be true among fossil Cephalopoda, and there exist, so far as known to the author, but few characteristics probably originating in the early stages. The constant recurrence of hereditary characteristics in silphologic and nealogic stages which originated in adults, like those given above for the Endoceratidæ, makes the probability of the assumption, that the asiphonula and veliger represent the adult stages of lost types, so highly probable, that the burden of proof must rest upon the opponents of this argument. Each case of the origin of characters in embryo and larvæ should in other words be regarded with distrust until proven.

The appearance of the incomplete modes of segmentation in existing Sepioidea may possibly be a case of origination in embryo. There are no adult forms known to the author, which store up food in their tissues in such a manner that they can be used to explain the origin of the specialized food yolk. Nevertheless special inquiry might have very unexpected results. The case above given of the calcareous nature of the protoconch, and all the other characters of the stage in the Ammonoids and Belemnoids, seemed to have originated in embryo until it was found that a distinct silphologic stage, the asiphonula, existed in Nautiloids, and that this indicated the former existence of an asiphonulate ancestor having a calcareous shell.

Some of the characters of the goniatitinula, such as the deep ventral saddle of the first septum in the angustisellate young, as described by Branco, doubtless originated in the younger stages. These are, however, correlative with the anarcestian form of this

stage and with a general tendency to closer involution, which acted the same way in every series of forms, whether we select series of adults or of embryos for comparison.

The use of a distinct term for the adult period becomes necessary not only on this account, and to separate its relations from those of preceding periods, but also because of the constant recurrence and importance of representative forms. The term Ephebology [1] has accordingly been adopted for the designation of the relations of the adult stages, and under this term can be classified also the representation of similar forms in different groups or morphological equivalents. These are often so exact that it becomes very difficult to separate them. They have been and will continue to be the most difficult and misleading obstacles to the student of genealogy and classification.

In former essays we have described and defined the senile transformations and their correlations with the degraded forms of the same groups. The nature of these relations is, as has been explained, quite distinct from those of the progressive and adult stages, but the correlations are nevertheless equally important for the classification and tracing of genealogies during the declining period of a group, and in the case of degraded and aberrant forms. We have, therefore, for some years past designated these relations by the term Geratology.[2]

This nomenclature is similar to that adopted by Hæckel, but is, when properly considered, also supplementary and based upon morphological rather than physiological grounds. This eminent author regarded the ontogeny of an individual to be divisible into three periods: first, the stages of Anaplasis or those of progressive evolution; second, the stages of fulfilled growth and development, Metaplasis; third, those of decline, Cataplasis. He also appreciated and gave full weight to the general physiological correlations which are traceable between the history of a group and the life of an individual, and, in accordance with these ideas, designated the progressive periods of expansion in the phylogenetic history of a group as the Epacme, the period of greatest expansion in number and variety of species and forms as the Acme, and the period of decline in numbers of species, etc., as the Paracme.

[1] *Ἔφηβος*, the age of puberty.

[2] *Γέρας*, old age.

Hæckel used also the term Anaplastology for the physiological relations of the stages of progressive growth and those of the Epacme of groups, Metaplastology for those of the adult and the Acme of groups, and Cataplastology for those of the senile stages and the Paracme of group. These terms seem to cover the same ground, as those we have employed, but they were in reality chosen for the purpose of classifying physiological relations. Thus the anaplastic relations of the Embryologic, Silphologic and Nealogic stages to the phenomena occurring in the Epacme of groups, and the metaplastic relations of the Ephebolic stages to the phenomena occurring at the Acme of groups, and the cataplastic relations of the Geratologic stages to the phenomena occurring during the Paracme of groups, are the functional relations of one class of morphological modifications to those of another class and do not properly include the morphological phenomena themselves or their morphological correlations.

The necessity for a double set of terms may possibly not be at first admitted by many zoologists on account of their too exclusive devotion to the morphological side of their studies, but a very slight experience in trying to express the serial correlations of morphological and physiological phenomena will very soon show them, the convenience of such a nomenclature. Geologists have already arrived at this conclusion with regard to the classification of strata in the earth's crust and have begun to use two parallel series of terms, one giving the nomenclature of the relations in time, Era, Period, Age, etc., and the other the faunal relations under the headings of Group, System, Stage, and so on.[1] The time has come for recognizing a similar parallelism between structural or statical phenomena of organisms and their dynamical or physiological relations in time, and it is necessary to separate these clearly by different series of terms in order to see not only how they are separable, but also their correlations.

We have been more or less constantly observing and publishing on the Geratologic stages among fossil Cephalopoda for more than twenty years and have repeatedly described the more or less exact comparisons, which can be made between the different stages of decline in the individual and the degraded forms occurring in the same group.

[1] G. K. Gilbert, Address, Am. Ass. Adv. Sci., 1887.

There were two stages in the old age period among Ammonoids: the first of these can be designated as the Clinologic[1] stage. This immediately succeeded the ephebolic period and during its continuance the nealogic and ephebolic characteristics underwent retrogression. Ornaments, spines, and sutures degenerated and lost their angularity, the ribs of pilæ, and often the keel and channels, when the latter were present, became less prominent, and before this stage closed the whorl itself sometimes decreased, showing that degeneration in the growth force of the animal had taken place. Similar phenomena can be easily observed in other departments of the animal kingdom, notably in man, whose habits tend to preserve life until he has attained extreme age. During this period there is a steady loss of the differential characters acquired during the stages of progressive growth and there is a tendency to resume the proportions and aspect of the earlier nealogic stages. In man, baldness of the head, loss of teeth and resorption of the alveoli, loss of the calves, rotund stomach, and the return of early mental peculiarities, are phenomena of similar import.

The last changes in the ontology of the animal may be termed the Nostologic stage,[2] and during this stage these tendencies reached their highest expression. Among Ammonoids the ornaments were all lost by resorption, the whorl became almost as round and smooth as it was in the silphologic stage, and in extreme cases it was separated from the next whorl, leaving a perceptible gap. This almost complete reversion to the aspect of the silphologic stage can of course only occur in animals which attain an extreme age.

The correlations of Clinology are exact, and indicate the changes which may be expected to occur in the same group whenever degraded or aberrent species can be traced in a more or less continuous series of graded modifications starting with any given normal form. Many such series have been traced, and these are recognized now by all palæontologists as genetically connected. They began with normal, close coiled, ornamented, shells, the descendants were smaller, showing a tendency to be less involved by growth, to lose their ornaments, and simplify the outlines of the sutures, though

[1] *Κλίνω*, to incline downwards.

[2] *Νόστος*, a return.

they had coiled young stages similar to those of the normal forms from which they must have originated.

The correlations of Nostology can only be artificially separated from those of Clinology, but there existed one class of forms which can be compared only with the nostologic stage. These are the degenerate straight Baculites-like shells, which belong to several distinct genetic series and should often be widely separated on that account. Their resemblances are undoubtedly close, but they are due to degeneration and, therefore, simply homoplastic. Naturalists sooner or later will begin to recognize that degeneration may produce close representation in forms having distinct origins. The Baculities is a smooth, straight, cylindrical though slightly compressed shell, which has so completely reverted that it resembles an Orthoceras, though it is an unquestionable Ammonoid of the Jura and Cretaceous.

THE POISON-APPARATUS OF THE MOSQUITO.

BY PROFESSOR G. MACLOSKIE.

THE oral armature or proboscis of the mosquito (*Culex*) is described and figured in Dimmock's *Mouth-parts of Some Diptera*, and consists of a labrum, two mandibles, two maxillæ, surrounding a hypopharynx, and all these enclosed in a loose scale-covered sheath, which is the labium. They are nearly three millimetres long, about four times as long as the head; and all except the sheath are smooth, chitinous stylets. The maxillæ bear maxillary palps, scaly, four-jointed, about as long as the head in *Culex*, and three times as long in the allied genus *Anopheles*. I have only to add to Dimmock's description that besides the somewhat coarse serration of the maxillæ (about fifteen teeth near the top of each), Minot S. Morgan, of Princeton, has shown very fine serrations on the upper part of the mandibles (about forty-two minute teeth on each).

The hypopharynx is in the axis of all these mouth parts, being inserted by a basal enlargement close behind the oral aperture, and

flattened so as to form the floor of a sucking tube whose sides and roof are formed by the grooved labrum (or labrum-epipharynx according to Dimmock). This sucking tube extends back in the head, piercing between the upper and lower brain, and enlarged in the posterior part of the head into a large pumping organ, which forces the imbibed fluid backwards into the œsophagus and stomach.

In the last century Reaumur thought he could detect a drop of saliva ejected by the proboscis when stinging; he supposed that this is poisonous, and that its special function is to prevent the coagulation, and thus to promote the flow of blood by suction when the insect operates on our skin. We do not believe that he possessed any instrument that could show the poison; but his inference as to the presence of poison and its function is almost certainly correct. It seems to us, however, that the chief food of this insect is not animal blood, but the proteids of plants; and probably the fluid ejected may prevent the coagulation of all proteids, and so promote the process of suction.

It has been very often suspected that the poison-duct is contained in the hypopharynx, which has a thickened axis, like a rod, supposed by some observers to be tubular. Dimmock made out the tubular character of the corresponding part of some of the larger non-poisonous Diptera, but he was not able to demonstrate its tubular character in Culex. In addition to his observations that go to prove the existence of poison in its bite, I may add my own observation, that even when failing to draw blood its bite will sometimes swell the part, the subcutaneous tissue being irritated by poisonous matter. He concludes from the careful examination of all the parts that no other channel can conduct this poison; and adds, "This, together with the position occupied by the salivary duct in other Diptera, leads me to believe, without as yet being able to give anatomical proof of it, that the hypopharynx of Culex contains a duct that pours out its poisonous saliva"; and he further states that he was unable to determine the actual presence of the glands.

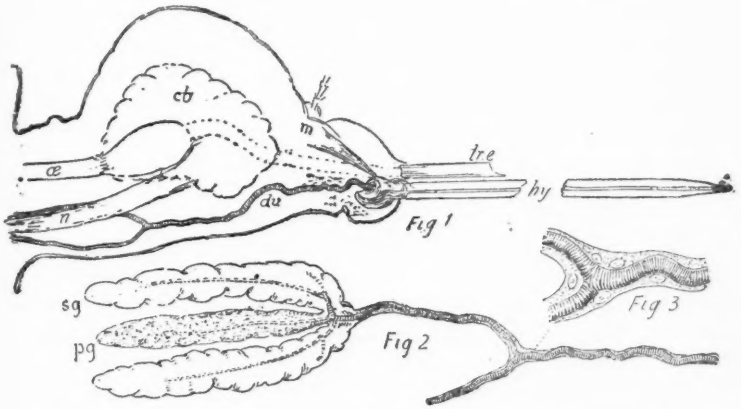
A year ago I succeeded in making out the duct and also the glands, and published a preliminary note; I was unable, however, at that time, to correct errors or to complete the work. This

past summer, however, gave me an opportunity of revising the subject, so that I have acquired some facility in finding and dissecting the parts. I find that it is even easy to see the venomo-salivary duct from the outside, shining through the skin at the base of the head and neck in the undissected specimen. Also, thanks to the supervision of Professor Libbey and the manipulation of Dumas Watkins, of Princeton Histological Laboratory, I have been supplied with a set of excellent sections, which show the relations of the parts. One of these sections is here engraved in part (Fig. 1), exhibiting the insertion of the duct into the base of the hypopharynx, and its course below the nerve. I have also teased out and stained some of the glands, which have enabled me to show their structure and relations, as in Fig. 2.

The secret was first discovered by an observation of fine droplets of a yellow, oily-looking fluid escaping from the apex of the hypopharynx (Fig. 1). I was then able to trace the course of this fluid down through the axis of the hypopharynx, its being divided in parts into droplets, and so indicating the tubular structure of this organ. On examining the base of the hypopharynx I found it to be enlarged like the mouth of a trumpet, and provided with a sac-like reservoir, into which the end of a fine duct was inserted. Working backwards I saw the duct to be of the usual character of salivary ducts in the Diptera, but much finer than usual, being less than eight microms in diameter, against thirty-seven microms in the house-fly.[1] It is not readily identified by a low microscopic power, and this may explain why it has not been previously detected. It has the usual chitinous lining, surrounded by the nucleated hypodermis which secretes it, transversely striated as in tracheæ (Fig. 3); but it is distinguished from the tracheæ by the comparative smallness and constancy of its diameter, and by the absence of ramifications. It runs back in the lower part of the head, beneath the nervous commissure (*n* in Fig. 1), for two-fifths of a millimetre. In the throat it bifurcates, its two branches being each as long as the undivided segment, and running on the right and left of the nerve-cord into the prothorax, where they terminate in glands of characteristic structure.

[1] A microm is one-thousandth part of a millimetre, or one-twenty-five-thousandths of an inch.

The glands are in two sets, one on each side in the antero-inferior region of the prothorax. Each set consists of three glands, two of which are of the usual aspect of salivary glands, resembling in structure, but not proportionately as long as, the single salivary gland on each side in the prothorax of the house-fly. The third gland, that occupying the centre of each set, is different, being evenly granular, and staining more deeply than the others; its function being without doubt the secretion of the poison. Each gland is about one-third of a millimetre long, and one twenty-fifth of a millimetre broad; the three are arranged like the leaves of a trefoil; and each is traversed throughout by a fine ductule, the three ductules uniting at the base to form a common duct, which is like a pedicel of the trefoil and is one of the branches of the bifurcated venomo-salivary duct. The ductules of the lateral glands of each set receive a minute branchlet near the base. Thus there are six glands, three on each side, two of them poisonous and four



EXPLANATION OF FIGURES.—Fig. 1. Median section of head, showing (*du*) the venomo-salivary duct, with its insertion in (*hy*) the hypopharynx: *cb*, cerebrum; below this is the cerebellum, and the pumping enlargement of (*œ*) the œsophagus: (*lr. e.*), base of labrum-epipharynx; (*m*) muscle; (*n*) nerve-commissure. Other parts removed.

Fig. 2. The venomo-salivary duct, showing its bifurcation, and the three glands on one of its branches: (*pg*) poison-gland; (*sg*) marks the upper of the two salivary glands.

Fig. 3. The bifurcation of the duct, with its nucleated hypodermis.

salivary, their secretion diluting the poison. The two efferent ducts, one from each set of glands, carry forward and commingle the venomo-salivary products in the main duct: and the stream is then carried by the main duct to the reservoir at the base of the hypopharynx. There is no other exit for the contained fluid. I see muscles apparently inserted on the frame-work of this reservoir (Fig. 1, *m*); but Dimmock seems to think that the hypopharynx is not furnished with muscles. However this may be, the pressure exerted on it by the surrounding parts, when the mosquito inserts its piercing apparatus into the flesh or through the epidermis of a plant, is sufficient to propel the poison through the tubular axis of the hypopharynx into the wound. The reservoir must be furnished with a valve to prevent the reflux of the secretion. The distal orifice of the hypopharynx is not exactly terminal, but sub-apical, as is usually the case with fangs; the very tip is somewhat flattened and sharp, so as to enter easily into and to enlarge the wound made by the adjoining organs.

Careful observations are needed as to the behavior of mosquitoes on plants; as to the condition of the hypopharynx and the glands in the males and in the larvæ. The observations here noted were made on the adult females of Culex (*C. tæniorhynchus* Desv.), and on a species of the allied genus *Anopheles*, which is characterized by its long maxillary palps.

Princeton College, Sept. 18, 1888.

SOMETHING ABOUT CRABS.

BY J. S. KINGSLEY.

CRABBED, crusty, cancer, canker, are terms which at once recall to most persons various disagreeable features and more serious ailments of human beings; to the naturalist they at once suggest the crabs and the group Crustacea to which these animals belong. There must be some reason why the crabs have thus acquired this bad name which goes even farther than indicated above. They are by common consent regarded as ill-tempered, ready to pinch

upon the slightest provocation, and anything but straightforward in their actions. When a man begins "to crawfish" (the verb is sanctioned by usage, if not by lexicographers) he does not inspire respect. Yet who cannot recall some surly member of the community who is universally regarded as crusty and crabbed, but who, on more intimate acquaintance, reveals another character, quite at variance with the estimation in which he is popularly held? So it is with the crabs. Their crustiness is all external, and if one be willing to run the risk of an occasional nip, he will find that these much maligned creatures have many attractive aspects, and like the rest of nature they amply repay the time spent in their study.

Intellectually the Crustacea are supposed to rank pretty low in the scale, but it is an open question whether this inferiority be an actual one, or whether it results from deficient observation. We can take the ants into our studies and watch their every motion, but the crabs are not so easily domesticated; captivity does not agree well with most of them, and even with those which can be kept, the surroundings are so strange that we have an element entering the psychological equation the value of which it is not easy to ascertain.

Of all the Crustacea with which I have had personal acquaintance, none are more interesting, either in captivity or on their native beach, than the fiddler crabs, those apparently misshapen forms which throng every suitable stretch of sand along our shores from Cape Cod to the Gulf of Mexico. A picture is well in its way to illustrate the shape and general appearance of an animal, but no picture can present to us the animal in action, nor represent its varying moods and phases. The fiddler, with its quadrate body, its eyes seated on the tips of the slender erectile pedicels, those eight slender, sharp-pointed legs, and that enormous pincer, can readily be drawn, but the changing aspects of the body are beyond the artist's power.

When you draw near the beach where these crabs are abundant, no matter how cautiously you have approached, there is a hurried rush of myriads of these crabs, each scuttling away as fast as four pairs of legs will carry it, to a place of safety. At such a time the appropriateness of the common name is seen. In every direction are the fiddlers, each plying its small claw across the enormous fellow in the most amusing manner. No matter how often seen,

one cannot help thinking of the musician—usually bald-headed—away down to the left of the orchestra, who so vigorously saws the bass notes from the viol. Let the latter scamper away, viol and all, as rapidly as does the crab, and the simile would be complete. When, however, you seat yourself and allow the cancrine community to regain its wonted quiet, then you can study these forms to your heart's desire, and see the various occupations. Some are engaged in gathering food, others in building houses. None are idle, but there seems to be no general supervision, each individual following his own inclinations. The holes in which they live vary somewhat with the species. Those on Cape Cod excavate a simple tube leading to a cavity sometimes a foot or two beneath the surface. Further south an allied form appears which arches over the mouth of its burrow with an oven-like roof, beneath the shade of which the proprietor sits and watches for any approaching danger.

These fiddlers are rather remarkable among the crabs in that they live in pairs. Mr. Fiddler is the one who goes about, builds the house, collects the food, and fights the battles and defends the family honor. His faithful spouse is but rarely seen above ground, but what her duties are in her cellar home is a problem yet to be solved. You may at once recognize her by the fact that she lacks the fiddle of her other half. Both of her pincers—hands one might almost call them—are of the same size and resemble the smaller hand of the male, and she uses them indiscriminately in feeding the principal use to which they are put.

The fiddler crabs are usually said to be vegetarians, and, indeed, the greater proportion of their food consists of algæ. They do not, however, confine themselves to this diet, but will eat dead insects or crabs, and, in confinement, they will at times turn cannibals, and prey upon the weaker individuals of their own species. This may be prevented by feeding them often enough and a sufficient amount of vegetable matter. I have had them thrive for months in confinement upon crackers soaked in water, of which, though not their natural food, they appear to be very fond. When thus kept captive they afford very interesting pets, and their actions cause a good many questions. The care is extremely simple. First get your crabs and your jar or box of moist sand, put your

crabs in with the sand and the vivarium is stocked. All that is necessary to keep it in running condition is to occasionally moisten the sand, and to supply new food before the old is exhausted. Kept in this way fiddlers will readily live in confinement through the warmer months, and possibly through the winter as well, though I never tried to keep them so long. I had only male fiddlers, and these I kept in the ordinary glass fruit jars which were half filled with sand. This furnished them endless employment, for they were constantly digging new burrows and filling up those dug but a few hours before. Why this dissatisfaction I am not able to say; possibly it was a case of "Cœlebs in search of a wife."

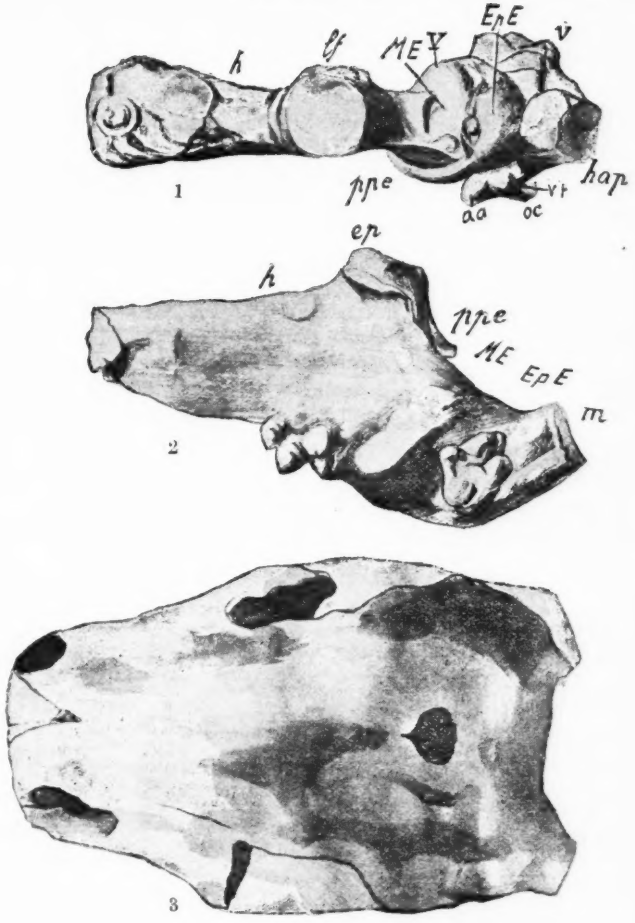
A fight between fiddlers is an amusing affair. When one sees his enemy approaching he immediately puts all his forces on a war-footing. The long-stalked eyes are erected so as to watch every motion of his antagonist; the big pincer furnishes not a bad imitation of the shield with which the soldiers of ancient times protected themselves, while the tension of every nerve is shown in the dainty way in which the eight walking legs trip over the sand, holding the body as high as possible in the air. At last the two meet. There is a clash of arms, each striving to grasp his antagonist and at the same time to protect himself, but might here takes the place of right, and the victor is he who loses the least number of members. There is no surgeon to bind up the wounds, but the amputation of a limb is not such a serious matter here as with human warriors. The yellowish blood which flows quickly coagulates and forms a covering for the wound, and then nature immediately sets about replacing the missing member. The way this is accomplished is so interesting and so different from anything occurring in the lords of creation that it deserves a moment's attention.

The crabs are covered with a hard and unyielding armor which does not admit of growth. So at intervals they shed their shell, and then form a new and larger one, which in turn will be cast to accommodate still further increase of size. In the fiddler crab the first sign one notices of the approaching molt is a splitting of the integument just where the slender tail (which is kept folded beneath the body) joins to the larger anterior portion.

Through the opening thus afforded the crab now withdraws himself, coming forth a soft-shelled, weak, flabby creature. Now he is a pitiable object. The claws, which before could pinch so sharply, are now limp as a rag. His meanest enemy would now find him an easy victim, utterly incapable of the slightest defence. On account of this unprotected condition immediately after molting, all of the Crustacea seek some sheltered spot when about to cast their skin, and hence the operation is not often seen. The process has its differences in the different species; thus the shell of the lobster splits down the middle of the back, while that of the horseshoe crab splits around the sharp front edge, so as to afford the opening through which the animal is to emerge.

There are, however, other processes which precede the splitting of the shell, which need to be mentioned, and which, as they have been most studied in the lobster, will be described as they occur there. First a word as to the nature of the shell. It is what is called a cuticular product. That is, it is not composed of cells like the rest of the body, or like the skin of man, but of a peculiar substance secreted by the cells lying beneath. Its density in various species differs not only with the thickness of this layer, but as well with the amount of carbonate and phosphate of lime which is deposited in it. It is this outer non-cellular layer which is cast at each molt, while the cells secrete a new shell. If one examines closely any crustacean they will see (more numerous and larger in some places) that all over the body there are small hairs, but these hairs differ from those of man in that they consist of the same cuticle as the rest of the body, and have an axis cylinder which arises from the cell beneath. It may also be said that these same hairs are organs of sense. One of the first preparations for a molt is the formation of new hairs and a new cuticle beneath the old one, and these new hairs have to lift and tear away the shell from the underlying shell. It is an interesting fact that in certain reptiles which "shed their skin," there are bristles which lift the old integument in the same way. Another feature to be noticed is the way in which the lobster withdraws its big claw, and probably the same is true of the fiddler, though this is mere surmise. If we examine a lobster we find that the pincer is much larger than the joints which connect it with the body, and it seems impossible that

PLATE XVI.



Cast of brain-case of Diadectes sp.

Figs. 1 and 2. Cast of cranial cavity, natural size. As the basicranial axis is lost, the inferior outline posteriorly is provisional only.

Fig. 1, from above.

Fig. 2, from the left side.

Fig. 3. Skull of *Diadectes phascolinus* Cope, from above.

he large muscles which close the pincers can pass through the small flattened rings of the intermediate joints. However, a change takes place in these before molting. There is an absorption of the calcareous matter on the inner surface of these joints, so that they lose their former rigidity and allow the passage of the parts beyond them. In this connection mention may be made of the "crab-stones"--small calcareous bodies occurring on either side of the stomach in Crustaceans about to molt. Although no definite knowledge exists as to the purpose of these masses of lime, it seems probable that they are stores which are to be drawn upon in hardening the new shell. Huxley thinks that this cannot be the case, because these bodies are of inconsiderable size in the crayfish, an argument of but very little weight.

But we are wandering afar from our subject—the way in which lost parts are reproduced in the crabs. Until a molt occurs the wounded veteran has to wander about without the limbs lost in battle, thin stumps seared over by the film caused by the coagulated blood. When the molt takes place we see a change. In the place of the lost leg there rapidly expands a new limb, which is like the old one in all respects except size. It is much smaller, but at the next molt it becomes as large as its fellow. A curious feature connected with the molting is that the lining of the stomach is cast at the same time with the outer shell.

We have explained above the reason why the fiddler crab has received its popular name, but he is in reality a true fiddler. Like many other crabs he has a means of making a noise, and the big claw is his musical instrument. On the inner surface of this member is a row of small rounded tubercles (their position varies with the species), and these can be rubbed against the edge of the shell, producing a note best likened to that caused by rubbing a quill toothpick over a file.

There are other crabs concerning which the popular literature is much greater than that relating to the fiddlers. Possibly more has been written about the hermit crabs than about any others, for certainly no one ever visited the shore without noticing these curiosities. They occur in all seas from the tropics to the poles, but wherever found all exhibit that common characteristic which has given them their name. We have all heard of that old Greek

Diogenes, who made his home in a tub, or, as others will have it, in a cracked amphora, and is it to be wondered that while naturalists were ransacking all ancient history and mythology for names, that the old philosopher should have to furnish a cognomen for some of these, his prototypes? A hermit crab needs protection for the hinder part of his body, for this is covered with a delicate cuticle and could be easily injured. The desired security is sought by inserting this "tail" in the cast-off shell of some univalve mollusc, the curl of the tail and the rudimentary limbs with which it is provided serving to hold the shell tight, and thus protected the hermit wanders over the bottom or along the beach safe from almost any enemy. The little hermits have small houses; the large ones have their larger cells into which they can retire for protection, and, who can say, not for meditation and prayer?

The house-hunting adventures of the hermits have been so frequently described that a repetition is useless. When the body grows too large for the old home a new shell is sought, its dimensions are carefully measured by claws and antennæ, and, if it be thought suitable, moving takes but an instant of time, and the hermit is in a new and larger home. All hermits, however, are not troubled with this frequent recurrence of moving day, for they have living homes, the growth of which is sufficient to accommodate their usual increase in size. They start in life with a borrowed shell, just as do their more familiar cousins of the shore, but a sea anemone helps them later. This latter animal becomes attached to the shell, feeds upon the crumbs dropped from the hermit's table, and grows as he grows. Soon the shell is covered, and then the anemone begins to spread and thus builds a tube for the crab. It goes further, for it absorbs the old shell, and with its own body gives all the protection which the crab needs. Thus the strange partnership goes on; the crab providing food—at least in part—the anemone furnishing the protection. In this respect the latter is far more efficient than the first glance at its soft and skeletonless body would indicate, for it is provided with stinging organs of no mean order, and many a fish is deterred from swallowing crab and all by the nettling it receives from this soft-bodied flower of the sea. A few years ago but a few of these cases of association of hermit crab and sea anemone were known, but more lately the deep-sea dredgings have furnished numerous examples.

This association of forms, which is known as commensalism—a term, a free translation of which would be fellow-boarders—receives numerous exemplifications among the crabs. One form, first described from the Pacific ocean by the late Dr. Stimpson, settles down upon a piece of growing coral, which then proceeds to build a protecting nest about it, leaving only openings for the ingress and egress of the water bringing food and oxygen to the prisoner. Even more remarkable is the case of the shrimp, which so far has only been found enclosed within the glassy network of that beautiful sponge, the "Venus-flower-basket." So strange was this association that when it was first noticed it was thought that those dextrous fingers of the east, which furnish those wondrous ivory carvings and which fashion those curiosity-exciting mermaids, had placed the shrimps within the sponge, and then had closed the opening so skilfully that the detection was impossible. It would now appear that this is not a counterfeit to be be laid at their doors.

Another strange case of commensalism is furnished by some small crabs which are more nearly related to the fiddler with which we started, and of which the little oyster crab is an example. These crabs live inside the valves of oysters, clams and other molluscs, and in olden times quite a pretty myth grew up about them. The delicate Pinna of the Mediterranean (a bivalve mollusc somewhat resembling our familiar salt-water mussel) was eyeless, and in order to escape the jaws of some wandering fish it had to be told when to close its shell. This position of watchman was filled by the little crab which was constantly on the alert, and which in return for its services was protected by the mollusc. This little crab was called Pinnotheres—guardian of the Pinna—and the same name is embodied in the scientific nomenclature of to-day. Relatives of the oyster crab seek other homes. On our Carolina coast is one which lives in the strong tubes built by one of the worms, while in the Pacific are found others which take up their residence in the posterior portion of the alimentary tract of certain sea-cucumbers or holothurians.

The fiddler-crabs are largely air-breathers. In fact, so long as they are in a moist location, where they are in no danger of drying up, they do not need to actually enter the water for weeks or months at a time. In this respect, however, they are equalled, if not excelled,

by several species (some their near relatives) which occur in tropical countries, the warmer portions of America possibly being their metropolis. These land crabs are strange creatures, which, like their marine relatives, are provided with gills, but which, unlike them, stay away from the water for months at a time, and which are drowned by submergence almost as quickly as any terrestrial mammal. There is a considerable diversity in their habits. Some frequent the lowlands near some stream or shore, while others, notably in Jamaica and on the Isthmus of Panama, live in the dense damp forests which clothe the highest mountains. They are not easily caught, for they can run with an agility which almost surpasses belief, while their strong pincers have powers of nipping which are not to be despised. Usually but a few are seen at a time, for during the day they rest in their burrows or in holes in the rocks, venturing forth for food only as evening draws near. Once a year, however, they are compelled to visit the shore to lay their eggs. They then appear in incredible numbers, year after year, on almost the same day. They march along in vast armies, turning to neither side for any obstacle, but devouring everything green in their line of march to the sea.

In connection with these terrestrial crabs many interesting physiological experiments are yet to be made. Years ago it was noted that besides the gills, the gill chamber contained a very thick and spongy lining membrane, which was of use in respiration, and several years later Professor Semper made similar observations upon an East Indian species, in which he recognized not only the spongy layer, but also ascertained that it was richly supplied with blood vessels; in short, that this organ, so far as function was concerned, is a veritable lung, though of course of a far different origin from that of the higher vertebrates.

SCIENCE-TEACHING IN THE SCHOOLS.

BY WM. NORTH RICE.

[Continued from page 774.]

BUT many who concede theoretically the desirableness of the study of natural science in the lower schools, maintain that the practical difficulties in the way of its introduction are insuperable. It is objected that we have no competent teachers, no adequate material facilities, and no time in the already crowded curriculum. Science-teaching in the lower schools, it is said, belongs to that far-off millennium

> "When the war-drum throbs no longer, and the battle-flags are furled,—

when a constitutional amendment has abolished alcoholic fermentation, and made vice forever impossible,—when governments, no longer compelled to support military, naval, and police forces, can spend the bulk of their revenues on education,—when every primary school can have a well-equipped laboratory, museum, and observatory,—when every primary school teacher is a Ph.D. of a German university,—and when a reformed orthography has added about three years to school life, by obviating the necessity of spending that time in learning to spell. I believe, however, that the reform is thoroughly practicable. My own official duty, as a member of a college faculty and of a city school board, has required a careful study of all parts of the educational curriculum in a thoroughly practical spirit. And I should regard the general discussion I have given as of little value, unless I could propose some definite and practicable measures.

The most serious difficulty in the introduction of natural science into the lower schools is undoubtedly the lack of competent teachers. That the mass of our teachers are incompetent for any very high quality of science-teaching, is a truth as unquestionable as it is melancholy. That much of their teaching will be merely bookish,—that much of it will be so blundering that the scholars will have a good deal to unlearn,—is very certain. This difficulty has

been so strongly felt by many scientific men, that they have despaired of any successful science-teaching in the schools till a new generation of teachers can be raised up. "Better no teaching at all than poor teaching," is the principle on which they feel themselves reluctantly compelled to advocate the postponement of a reform whose need none can feel more strongly than they. But I believe the worst teaching we are likely to get is better than none. Very poor teaching of science will at least serve to keep before the mind of the child the idea that there is an external world which is worthy of attention and study. Better that many errors should be learned, than that the child should grow up without thinking of nature at all. No habitude of mind that is likely to be generated by poor teaching can be so bad as the habitude of stolid indifference which is the natural result of the present system. If we wait for teachers well prepared, before we introduce science-teaching, we shall wait indefinitely. Teachers will prepare themselves after a fashion to teach whatever they are required to teach. No way of making a boy swim has ever been found so effective as putting him into the water.

There are books in abundance (and the number is constantly increasing), from which a teacher possessed of a fair degree of mental activity can get suggestions which will enable her to do a limited amount of science-teaching soundly and well. Paul Bert's "First Steps in Scientific Knowledge" is an admirable guide for teachers of elementary science. Morse's "First Book of Zoology," and Winchell's "Geological Excursions," are books in which acknowledged masters of science have shown how science may be taught to the young. The series of scientific tracts for teachers now being published under the auspices of the Boston Society of Natural History are good, as judged from both the scientific and the pedagogic standpoint. Worthington Hooker's books of science for children, though now somewhat behind the times, are still attractive and helpful books. And the teacher who cannot find something to interest the youngest in Johonnot's series of natural history readers, with their delightful blending of fact and fancy, the science and the poetry of animated nature, is stupid indeed.

The teaching of science in the lower schools can be considerably helped by the teachers in the high schools. In most high schools it is practicable to obtain the services of one or more teachers who

have had some genuine scientific training. Arrangements can be made whereby these teachers can now and then give a helpful lecture to the teachers of the lower schools, or give to those teachers the best kind of an object lesson by teaching a lesson in science to the children in their schools.

The summer schools and seaside laboratories afford the means for teachers whose early opportunities for scientific study were scanty, to gain a sound (though necessarily limited) knowledge of scientific facts and methods. The increasing number and the increasing patronage of such institutions is a hopeful sign. They are destined to be of immense service in improving the quality of science-teaching.

The second objection usually urged against the introduction of science-teaching in the lower schools is the lack of material facilities. The force of this objection, however, vanishes, when it is considered that no one proposes for the lower schools complete systematic courses in science. Such courses would indeed demand extensive laboratories and museums. But for somewhat desultory lessons on judiciously selected topics in science, whose aim is primarily to cultivate the powers of observation, and secondarily to afford glimpses of the methods of scientific thought, no extensive material facilities are needed. Many of the most important principles of physics and chemistry can be well illustrated with no apparatus except what can be extemporized. A class of tolerably active boys can collect enough material for biological study as they go along. Many of the most important conceptions of philosophical biology can be illustrated without any specimens which are not everywhere accessible. A boy who has found the elbow, wrist, knee, and ankle, in a cat, a horse, a bat, and a hen, has learned the idea of homology, though he has never compared the arms of a brachiopod with the lophophore of a bryozoan, and never heard of the gastræa theory.

The third objection usually made to scientific study in the schools —the lack of time in the crowded curriculum—hardly deserves an answer. Let the waste of time and mental energy be stopped, which is involved in attempting studies at unnatural times and in unnatural ways, and there will be time enough. Of all economies, the most important is the most neglected—the economy of mental effort. I believe the introduction of science-teaching in the schools will be felt by the pupils as a delightful recreation, rather than as

an additional task; and that the improvement of morale will actually enable the schools to accomplish more in other studies.

It remains, then, to outline briefly the work which may be profitably attempted. In the primary schools, and the lower grades of the intermediate, or grammar, schools, the main objects must be to keep alive the child's curiosity in regard to natural objects, to cultivate the power of accurate observation, and to impress the mind with the idea that nature is worth studying. The attempt to teach any systematic body of facts and doctrines, so far as it is made at all, must be strictly subordinated to these more general objects. Hence it is no matter how desultory the lessons may be, if they tend to keep the mind of the child in loving communion with nature. The pupils should be encouraged to collect and bring to school specimens of all sorts of natural objects. So far as time allows, each specimen should be the subject of a lesson. Judicious questioning should bring out all the facts and phenomena which the child has observed or can observe in regard to the specimen. Then the teacher should add something of explanation or information in regard to the object itself or other related objects. And let questions be suggested now and then, which the child and his elders are alike unable to answer. Thus the child will become early habituated to the complementary truths of the transparency and the unfathomableness of nature. He will learn that he can see into nature a little way for himself, but that beyond his vision stretches a vast unknown. The specimens brought in will be an utterly heterogeneous collection—now a bright-winged butterfly, now a flower, now a plant with insect galls, now a sea-shell brought home from some summer visit to the sea-side, now a lustrous crystal, now a smoothly rounded pebble. All the better. Let the children learn the manifoldness of nature. It will be time enough later for them to survey the fences of systematic definition which man has run through nature's continuous and illimitable fields. Short excursions in the woods and fields (or in the parks which afford almost the only glimpses of nature to the unfortunate children who are brought up in the great cities), and visits to museums, zoological gardens, and menageries, will be helpful supplements to the work of the school-room.

Besides the utterly desultory lessons already considered, a beginning may be made in the primary schools in somewhat more sys-

tematic teaching. The objects most interesting to children are living things—plants and animals. Botany and zoology should accordingly be the principal subjects in the science-teaching in the lower grades. The comparison, drawing, and description of various forms of leaves, will furnish delightful occupation and valuable discipline for the youngest children. A little later the more easy and conspicuous flowers can be studied, and later still the more obscure and difficult flowers. In zoology, attention should be given not to crinoids and hydroids and infusoria, but to the mammals and birds and reptiles and fishes and insects which the children can see alive. In places immediately on the sea-shore, some of the more conspicuous marine animals may advantageously be included. The most common and familiar mammals, as cats, dogs, horses, rats, should be first studied; and rudimentary ideas of homology and teleology and the principles of classification can be developed in the study of these most familiar objects. From mammals the study may proceed in later years to birds, and then to the less familiar lower classes of vertebrates, and later still to arthropods and molluscs. Along with the change of subjects, there will naturally be somewhat of a change of method. There will be less of simple observation and description of external characters, more explanation of anatomy and physiology, and more discussion of general relations.

In several of the States, laws have been passed, requiring in all the schools instruction in physiology and hygiene, with special reference to the effects of stimulants and narcotics. There has been an element of fanatical exaggeration in the philanthropic agitation which has led to such legislation, and some of the books which have been prepared, and some of the teaching which has been done, in obedience to the demand, have not been of great scientific value. I believe, nevertheless, that simple lessons in physiology and hygiene may with great advantage be commenced in the primary schools. It is indeed true that physiology can be taught only in a very unsatisfactory manner to pupils ignorant of chemistry and physics, for physiology is essentially chemistry and physics applied to the complex structures and actions of the living body. But very imperfect knowledge is better than absolute ignorance. And the immense importance of the subject, in connection with the fact that only a very small minority of the pupils will ever reach the

high school, more than justifies the attempt to teach some rudiments of physiology in the lower schools.

Somewhat of physical geography will naturally be taught in the higher grades of the primary, and the lower grades of the grammar, schools, in connection with the general course in geography. It is very gratifying to observe the change in the school manuals of geography within the last few years, in respect of the greater prominence given to physical geography.

In the higher grades of the grammar schools, it may reasonably be assumed that the reasoning faculties are more fully developed than in the lower grades, and observation and description of forms may rightly give place in large degree to studies in which the relation of cause and effect is emphasized. This will be the most convenient period for the introduction of exceedingly elementary courses in physics and chemistry. The pupils who will never enter the high school ought to get some rudimentary knowledge of these sciences; and a like rudimentary knowledge obtained in the grammar school will be of great advantage to the students in the high-school course. Of course, at this stage it will not be desirable or possible to penetrate into the mysteries of polarized light, to enumerate the scores of rare elements, or to discuss the more intricate problems of the chemistry of the compounds of carbon. But it will be possible, in the later years of the course in the grammar school, to learn some of the more important facts and principles in regard to gravitation, the mechanical powers, the simpler and more obvious phenomena of sound, light, heat, and electricity, the distinction between elements and compounds, combustion, the chemistry of air and water, and the properties of a very few of the most important elements and their compounds.

When the student reaches the high school, he will be possessed of some knowledge of the forms of common animals and plants, the structure and functions of his own body, and the general properties of matter. What is more important than any knowledge of nature which he may possess—he will have kept himself in sympathetic communion with nature; he will recognize nature as a worthy object of study; he will know that he can learn something himself by the observation of nature, but that he has learned only an infinitesimal part of what nature has to teach. His conceptions will be crude, indefinite, inaccurate. His knowledge will require

elaboration, systematization, correction. But he will not find the book of nature written in a language whose alphabet he does not know. As he comes to the systematic study of the various sciences he will not feel that utterly bewildering sense of strangeness with which teachers in our high schools and colleges are now so sadly familiar. In the high school, he will come under the instruction of teachers possessed of larger knowledge, and supplied with more extensive material facilities. Now then the time has come for *systematic* teaching of science. Random observation and desultory stories of nature must now give place in large degree to the presentation of systematized bodies of fact and theory.

With the beginning of the high-school course comes the separation between those who are preparing for the classical courses in the colleges, and those who are destined to go from the high school directly into practical business life. For the former class the systematic study of science may be mainly deferred until they can enjoy the larger material facilities afforded by the laboratories, museums, and observatories of the colleges. I believe, however, that the complete exclusion of scientific studies from the classical courses in many of our high schools is greatly to be regretted. There are three scientific studies which I would have placed early in the high-school course, and required of both the English and the classical students.

First in this list I would name phænogamic botany. There is no study which can conveniently be made to furnish so admirable a discipline in observation. The material is everywhere accessible in abundance. The collection and dissection of the specimens involves no infliction of pain upon sentient creatures. The débris remaining after a lesson is comparatively clean, inodorous, and wholesome. In all these respects phænogamic botany is better adapted for thorough practical study at this stage than any branch of zoology. The structures which are to be examined in the analysis of flowering plants are also of about the right size to afford the most valuable discipline in accurate observation. The work is neither too easy, nor too difficult. It requires the use of the inexpensive simple microscope, but not the use of the costly compound microscope. A thorough training in plant analysis at this period of the educational course will afford a mental discipline which can be supplied in no other way.

Secondly, I would require of all students at this stage the study of human physiology. The immense practical importance of this branch of knowledge is a sufficient reason for this recommendation. The outlines of physics and chemistry which I suppose to have been taken in the later years of the grammar-school course, will enable the teaching to be more thoroughly scientific in method than can be the case in the lower schools. And, while the study cannot be made so much of an observational discipline as botany, there is no lack of material for demonstration. Most of the organs of the body present the same general character in other mammals as in man. Hearts, lungs, brains, and eyes can readily be obtained from the butchers, and a superfluous cat can be occasionally sacrificed. And, with the various convenient guides to mammalian dissection which have been published, there is no reason why a high-school course in physiology may not be illustrated with a fair amount of demonstration.

Thirdly, a systematic study of physical geography will be invaluable in giving the student an appreciation of the world as a whole —its unity in variety—unity of law amidst endless diversity of phenomena. No study so opens to the student's intelligence the language of nature, teaching him to read the lessons written in the ever varying landscapes which he may from time to time behold.

It is, in my judgment, greatly to be desired that these studies should be included in the requirements for admission to the colleges. As students naturally desire to enter college as early as possible, there is a strong tendency for the preparatory schools to exclude from their classical courses everything not required for admission to college. The requirement of a small amount of natural science by the colleges would greatly favor the progress of the reform in the schools.

For the students in the high school who are not in the classical course, there should be in addition systematic studies of physics, chemistry, zoology, geology, and astronomy. For them, natural science should certainly be a required study during the whole of the high-school course.

While the study of natural science has been advocated on the twofold ground of its practical and its disciplinary value, it has been assumed in this discussion that these two objects are by no means of equal relative importance in the study of different branches

of science or in different periods of the educational course. The study of botany has been advocated especially for its disciplinary value, that of physiology especially for the utility of the knowledge which is acquired. It has been maintained that in the primary school the main objects of the science lessons must be to cultivate a habit of accurate observation and intelligent appreciation of nature, while in the high school each science should be taught as a systematic body of fact and theory. This leads us to notice the unfortunate truth that the two objects of scientific study are to a certain degree incompatible with each other—that the best methods for mental discipline are not the best methods for the acquisition of information. Undoubtedly the method by which the characteristic mental discipline of scientific study can be most effectively secured, is to put the student as nearly as possible in the attitude of the original investigator—to lead him to infer laws and principles from the observations and experiments which he has made himself. But the path taken by the original explorer of a country is often not the most convenient route for subsequent travelers. And a knowledge of laws and principles in science once ascertained can often be taught in ways far more expeditious and convenient than the method of their original discovery. Moreover, many of the most important conclusions rest upon observations only possible in exceptional conditions of time, place, and circumstance. Every student should learn the laws of definite and multiple proportions, which form the foundation of chemical theory; but the ordinary student has no time to perform such a number of experiments in quantitative analysis and synthesis as would make a sound inductive basis for those laws. Every student should learn something of the phenomena and laws of earthquakes and volcanoes; but it is impossible to get up an earthquake or a volcanic eruption for a laboratory experiment. It is well for every student to learn something of the conclusions in regard to the action of the stomach reached by the classical observations on poor Alexis St. Martin; but it is hardly desirable to repeat St. Martin's accident and injury for the benefit of every class in physiology. The right method of scientific education must be a compromise. The most important facts and principles must be taught by text-books and lectures, in such way as to secure most effectively their being understood and remembered. But, so far as the nature of the sub-

ject and the time and means at the disposal of the teacher may allow, mental discipline must be secured by having the student tread for himself the path of observation and experiment, comparison and inference.

This difficulty in science-teaching is somewhat relieved by the consideration that a single fact learned by actual observation or experiment, serves to render real the knowledge of allied facts made known by the second-hand process of description, which would otherwise be shadowy and unsubstantial. The student who has made a few quantitative determinations in chemical analysis, understands the meaning of the analyses which he finds in books. The student who has handled the bones of one animal, can read intelligently the description of other skeletons.

In conclusion, I would most emphatically repeat that a plea for the study of natural science is not a plea against other studies. All the studies which have a place in the educational course, have their place by reason of their capacity to afford sound mental discipline and useful knowledge. All true education is broadening and liberalizing in its tendency. Whatever the special studies which natural tastes or professional plans may lead the student to pursue in the later years of his educational course, or whatever the pursuits in which he may engage after leaving school, he will have learned, if rightly taught, an appreciative respect for all the great branches of study in which the human intellect has engaged. He will not despise the study of languages, bringing him into communion with the great minds of other ages and other nations; nor the study of language, interpreting the structure and development of earth's myriad tongues. He will feel the dignity of that pure truth which is embodied in mathematics, and will appreciate the immense utility of the applications of mathematics in the arts of a material civilization. He will have learned in due time that he has a soul as well as a body; and will appreciate the study of the human mind, as revealed to the direct gaze of consciousness, or as expressing itself in literature and history. And the double world of sensation and consciousness will disclose to him its highest meaning, in the revelation of Him

> "Whose dwelling is the light of setting suns,
> And the round ocean, and the living air,
> And the blue sky, and in the mind of man."

But, whatever sources of light may shed their beams upon his advancing intellect, the first star which rose above his horizon will never set. Whatever teachers he may listen to, the one whose gentle voice first roused him from the slumber of unconsciousness will never be forgotten. As his first lessons were from nature's teaching, she will have for his expanding mind lessons continually new. He will

> "Find tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything."

Note.—It is proper to say that the address was not written previously to its delivery before the Society of Naturalists; and that, in writing it in its present form, I have incorporated some ideas which were suggested in the discussion at the meeting, and some which have been the fruit of further reflection. The article is, however, in the main a reproduction of the address as given.

In July, 1888, the Board of Education of the City of Middletown, Conn., adopted a new Manual for the Schools of that city. The new course of study provides for instruction in Natural Science in all grades from the lowest Primary upward, on a plan substantially the same as that which I have recommended. As a sort of practical comment on the views of the address, I append an extract from the Middletown School Manual, giving the instructions to the teachers in the Primary and Grammar grades in regard to instruction in Natural Science. The portion of the Manual here quoted was written by myself in connection with the Superintendent of Schools, W. B. Ferguson, M.A.

Extract from the Manual of the Public Schools of Middletown, Conn.

NATURAL SCIENCE.

Introduction.—The object of elementary lessons in Natural Science is twofold:—to train the observing powers, and to give information. The former should be especially emphasized in the Primary Grades, and the two made about equally important in the Grammar Grades.

The teaching should be chiefly objective. Large, well-defined pictures may be used, whenever it is impossible to obtain the real objects; but it should always be borne in mind that the best pictures are poor substitutes for the objects themselves.

In the lowest grades, the teacher should studiously avoid the use of technical terms, whose meaning is unknown to children. The chief object here is, not to teach science, but to train to close and accurate observation, and to stimulate a keen interest in nature. In no grade should special emphasis be laid upon technical terms and classifications, though somewhat more attention may properly be given to them in the Grammar grades. All classifications should, so far as possible, be the result of observation and comparison on the part of the pupils. Let the teacher stimulate, direct, and name. Happy the teacher and fortunate the pupils, if, in this delightful work, the teacher judiciously combines speech and silence. An occasional talk, however, by the teacher on the subject before the class is both proper and desirable. Such talks should furnish information beyond the reach of the pupils' observation.

Every lesson should be carefully prepared. Aimless and irrelevant conversations are profitless. Allow and encourage the freest expression of what the pupils see. *Encourage the pupils to collect and bring in specimens. Elicit, by judicious questions, a description of what they have brought. Give them additional information. If necessary, postpone the subject till the next day, and learn something about it.*

GRADE I.

Physiology.—Regions of the body—head, trunk, limbs. Details of external parts. Uses of external organs. Hygiene of the skin —bathing.

Zoology.—Lessons on common mammals—*e.g.*, cat, dog, horse, cow, rat, squirrel. Let the pupils observe, compare, and describe these animals, as regards their external aspect and habits. Compare these animals with ourselves. Tell stories illustrative of habits of these and other mammals.

Botany.—Lessons on common plants. Teach pupils to distinguish root, stem, leaf. Compare leaves of different plants, as regards general form, margin, venation. Require pupils to draw and describe leaves of many plants.

GRADE II.

Physiology.—The framework of the body. Bones, joints, muscles. Exhibit anatomical diagrams. Teach the pupils to find in their own bodies some of the bones which can be easily felt through

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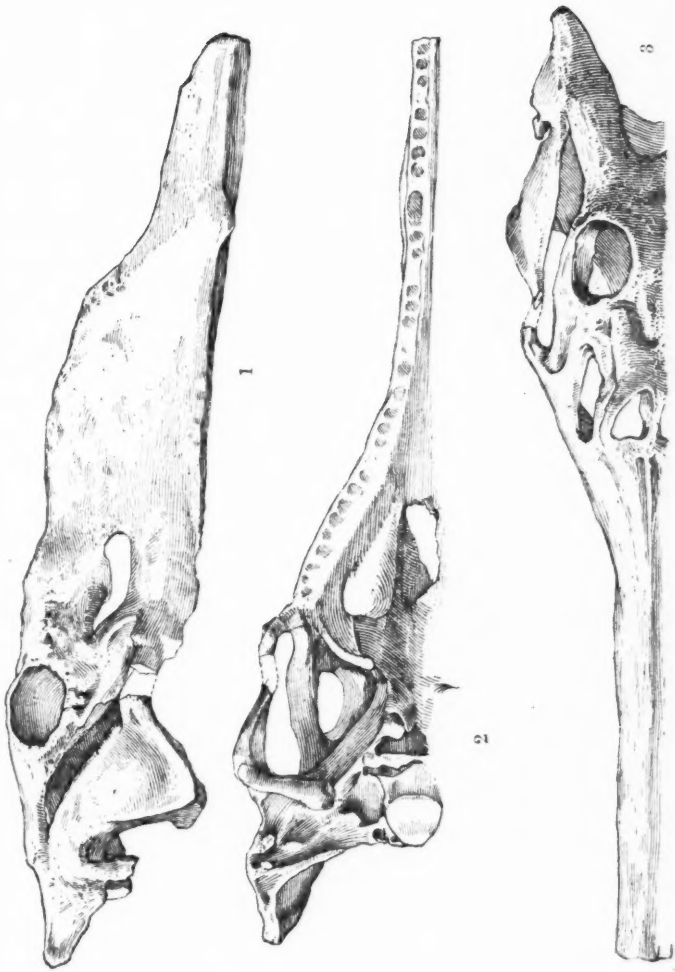
PLATE XVII.



Cranium of *Belodon buceros* Cope, from South western New Mexico.

the skin. Emphasize importance of correct attitudes while the framework of the body is rapidly growing and taking shape. Warn against stooping shoulders and crooked backs. The teeth—their forms and uses. Emphasize importance of proper mastication. Necessity of cleaning teeth.

Zoology.—Lessons on mammals continued. Special study and comparison of limbs of mammals. Let the pupils find the elbow, wrist, knee, and ankle, in the cat, dog, horse, cow, rat, squirrel, and any other mammals of which specimens or pictures may be at hand. Thus teach the idea of homology, though the word should not be used. Compare the teeth of common mammals, and lead pupils to recognize adaptation of different kinds of teeth to different kinds of food. Teach pupils to recognize degrees of resemblance between animals. The cat and the dog resemble each other more than either resembles the horse or the rat. Develop idea of classification. Lead pupils to recognize characters of carnivores, ungulates, rodents. Most of the mammals with which the children are familiar are included in these three orders. But tell them about monkeys and kangaroos and other very different forms of mammals, that they may not suppose that all mammals are so included.

Botany.—Different kinds of stems—woody and herbaceous, exogenous and endogenous. By study of numerous examples lead pupils to recognize that exogenous stems usually bear net-veined leaves, and endogenous stems usually bear parallel-veined leaves. Distinguish deciduous and evergreen trees. Let the pupils make lists of each.

GRADE III.

Physiology.—Elementary ideas of digestion. Why do we eat? All parts of the body are made of the food which we eat. Food is made into blood, and blood made into all the materials of the body. But our food is mostly solid, and must be made liquid before it can get into the blood. Different substances dissolve in different liquids—*e.g.*, salt in water, camphor gum in alcohol, iron filings in dilute sulphuric acid. Show these experiments. Body itself must make liquids which will dissolve food. Put lump of sugar in mouth. Mouth fills with saliva, and sugar is dissolved. This illustrates secretion of digestive fluids. But meat will not dissolve in saliva. What does become of it? Show

anatomical plate of stomach, and tell about gastric juice. Teach (with use of anatomical diagrams) outlines of anatomy of digestive organs. Show by experiment how much more quickly powdered salt dissolves in water than lumps of rock salt. Teach importance of thorough mastication. Show gizzard of turkey, and explain its use. But we have no gizzard; and hence must not swallow our food whole, as the turkey does. Wholesome and unwholesome foods. Alcohol.

Zoology.—Lessons on common birds—*e.g.*, robin, hawk, hen, duck. Let pupils compare these with each other and with mammals. Compare feet and bills of different birds, and show adaptation to habits. Continue lessons on homology of limbs. Let the pupils find elbow, wrist, knee, and ankle, in birds. Is the bat a bird? Talks on instincts of birds shown in periodical migrations and nest-building.

Botany.—Lessons on flowers. Select plants with perfect and somewhat conspicuous flowers. Teach pupils to recognize sepals, petals, stamens, pistils. Let pupils describe and draw the parts in a variety of flowers. Study polypetalous flowers first, afterwards monopetalous flowers. Cut open the ovary in large flowers, and show the ovules. Develop the idea that the parts of a flower are altered leaves.

GRADE IV.

Physiology.—Circulation. When food has been made into blood, blood has to be carried to all parts of the body—function of circulation. Show by anatomical plates the outline of anatomy of circulatory apparatus. Let pupils find some of their own veins, and feel pulsation of heart and of arteries in wrist and temple. Respiration. Show difference between inspired and expired air by experiment with lime-water. Burn a candle in a jar, and show that the air in the jar affects lime-water like expired air. Carbonic acid always formed when carbon burns—*i.e.*, when carbon unites with oxygen. Carbon in body and in food. Carbon burns—*i.e.*, unites with oxygen,—all over the body. Body runs, like a steam-engine, by burning carbon. Object of respiration—introduction of oxygen, and removal of carbonic acid. Anatomy of respiratory organs. Hygiene of respiration—dress, ventilation. Respiration in aquatic animals. Show gills of fish, and respiratory movements in living

fish. Fish breathes air dissolved in water. Show presence of such air by warming a beaker of water, and so forming air-bubbles.

Zoology.—Lessons on common reptiles, amphibia, and fishes—*e.g.*, turtle, snake, frog, perch, pickerel, eel. Let pupils observe, compare, and describe. Continue studies of homology of limbs. How many of these animals have two pairs of limbs like those of mammals and birds? Notice external covering of these animals. Their bodies are cold. Why? Respiration of fishes. Is the whale a fish? Metamorphosis of amphibia, as shown in changes from tadpole to frog. Teach characters of the three classes—reptiles, amphibia, fishes. Characters possessed in common by mammals, birds, reptiles, amphibia, fishes. Sub-kingdom vertebrata.

Botany.—The pistil of a flower developes into a fruit. Different kinds of fruits. Seeds. Show the embryo in beans and other large seeds. Plant seeds in pots, and show growth of plants from seeds. Cycle of growth, reproduction, death.

GRADE V.

Physiology.—Nervous system. Analyze the series of actions when a boy puts his hand on the radiator, and finds it too hot. Nervous system a telegraphic system in the body. Brain the central office. Afferent and efferent nerves. Anatomy of the nervous system. Hygiene of the nervous system—stimulants and narcotics.

Zoology.—Study the lobster. Lead pupils to recognize jointed external skeleton, distinct regions of body, jointed limbs. Trace similarity of structure in feelers, jaws and accessory jaws, nippers, legs, and other appendages, including the caudal fin. Cut off edge of carapace on one side, and show gills. Contrast articulate type of structure, as shown in lobster, with vertebrate type, as shown in animals previously studied. Compare diagrams of nervous systems in vertebrates and articulates. Compare with the lobster, the crab and the sow-bug. Teach pupils to recognize the common characters which unite these animals in the class crustacea. Study angle-worm, as illustrating articulate type in much simpler form—body not differentiated into regions, no jointed appendages. Talks on useful animals.

Botany.—Study more obscure and difficult forms of flowers than those examined in Grade III. Flowers densely aggregated, as in sun-flower, dandelion, daisy. Imperfect flowers, as in wil-

low, oak, chestnut. Flowers with open (gymnospermous) pistil, as in pine, spruce.

GRADE VI.

Physiology.—Briefly review work of previous grades. Special study of the eye. Anatomy of the eye. Illustrate formation of image on retina by use of a large lens. Hygiene of the eye. Injury of eye by use of light too strong, too feeble, unsteady, or improperly placed. Cultivation of near-sightedness by bad positions in reading and writing.

Zoology.—Study common insects, as the bee, butterfly, fly, beetle, squash-bug, dragon-fly, grasshopper. Compare these animals with lobster, sow-bug, and angle-worm, and recognize in all these the common character of articulates. In insects, note the characteristic division of body into head, thorax, and abdomen. Compare wings of insects as regards number, form, venation, texture. Show scales from wings of moth and butterfly under microscope. Examine the mouth parts of those insects which are not too small. Supplement observation with pictures. Under lens examine eyes of insects. Explain their peculiar structure. Metamorphosis of insects. Catch some caterpillars in the fall, and keep them in boxes in the school-room. Some of them will probably survive and appear as moths or butterflies early in the spring. Talks on injurious animals. Show how some animals are useful by destroying injurious animals —*e.g.*, insectivorous birds.

Botany.—Distinction between flowering and flowerless plants. Examples of flowerless plants—ferns, club-mosses, horse-tails, mosses, lichens, fungi, sea-weeds. Show fructification of ferns. Show that the distinction of root, stem, and leaf, so obvious in nearly all flowering plants and in ferns and others of the higher flowerless plants, vanishes entirely in fungi and sea-weeds.

Mineralogy.—Study crystalline form, cleavage, color, lustre, hardness, of some of the minerals common in the vicinity of Middletown—*e.g.*, quartz, feldspar, mica, hornblende, garnet, tourmaline, beryl.

GRADE VII.

Physiology.—Senses of hearing, smell, taste.

Zoology.—Study the river mussel. Direct pupils' attention to shell (with its hinge, ligament, mantle-impression, and muscular impressions), mantle, gills, palpi, mouth, foot, adductor muscles.

Compare this animal with the oyster and the clam. Note that the former has only one adductor muscle; while the latter has the mantle lobes united, forming a sack which is continued posteriorly in the breathing-tubes, or siphons. Examine some pond-snails. These will be found to resemble the preceding in their flabby, unjointed bodies, destitute of internal skeleton; but will be seen to differ in having a distinct head with feelers, and a spiral univalve shell. Examine shells of some of the sea-snails. Lead the pupils to recognize characters of Lamellibranchiata and Gastropoda, as classes of the sub-kingdom Mollusca. Contrast the Mollusca with the Vertebrata and Articulata. Give some talks on corals, sponges, and other animals lower in the scale than mollusks. Do not let the pupil suppose that the classes he has studied comprise the whole animal kingdom. Talks on geographical distribution of animals. Give a little idea of geological succession of animals.

Botany.—Geographical distribution of plants. Uses of plants. Relation of plants to animals.

Geology.—Gravel, sand, clay. Show that these result from the disintegration of pre-existent rocks. Erosion, transportation, and deposition by water. Study gutters and puddles for illustration of action of aqueous agencies. Conglomerate, sandstone, shale. Show that these result from consolidation of gravel, sand, clay. Visit Portland quarries. Other rocks are sediments not merely consolidated, but crystallized by action of internal heat. Study specimens of gneiss and mica schist. Contrast their texture with that of sandstone and other sedimentary rocks. Still other rocks have come up in molten condition from interior of globe—*e.g.*, lava, trap. Talks on volcanoes.

GRADE VIII.

Physiology.—Review nutritive functions, using elementary text-book. Illustrate subject with a few dissections.

Physics.—Elementary text-book. Illustrate with experiments, as much as practicable.

GRADE IX.

Physiology.—Review functions of relation, using elementary text-book.

Chemistry.—Elementary text-book. Illustrate with experiments, as much as practicable.

THE PINEAL EYE IN EXTINCT VERTEBRATES.

BY E. D. COPE.

THE discovery of the pineal eye in lizards is due to Leydig, who first recognized it as a probable sense organ in 1872. Dr. Graaf first determined its structural correspondence with the invertebrate eye in 1886. In the same year [1] Spencer examined a large series of Lacertilia, and pointed out the very diverse degrees of development of this organ presented by these reptiles. In 1882 Prof. Rabl-Ruckhard refers to the large parietal foramen of Ichthyosaurus and Plesiosaurus as indications of the existence of a pineal sense organ in those ancient reptiles, perhaps especially sensitive to temperature. In the NATURALIST for 1885 (p. 1029), the present writer stated that the Pelycosauria of the Permian epoch possessed large pineal eyes. Mr. Spencer expresses a similar opinion with regard to the extinct Stegocephala or labyrinthodonts of the carboniferous system, in his paper above mentioned. He there maintains also the homology of the median eye of the Tunicata with the epiphysis of the Vertebrata.

In a paper published in the NATURALIST of 1885 (p. 291), the present writer described the characters of the supposed fish *Bothriolepis canadensis*, and homologized the orifice in the superior wall of the anterior part of the carapace (supposed to represent the head) with the orifice or mouth in a corresponding position in the Tunicata, especially referring to Chelyosoma, as having a general resemblance to Bothriolepis. I mention (p. 290) that a plate covers the middle part of this orifice, forming a median valve of the mouth, a character which is also described by Whiteaves in 1887.[2] It was already described in the allied Pterichthys by Pander and Owen. This plate covers the median part of the superior orifice, and leaves the lateral parts open. It has little fixity in the specimens I have examined, for which reason I called it a valve. See plate XV.

Subsequently I described the genus Mycterops[3] from the coal

[1] Mr. Spencer's paper is dated 1885, although he quotes De Graaf's and my own papers published in 1886.

[2] Illustrations of the fossil Fishes of the Devonian Rocks of Canada: Transac. Royal Society of Canada, 1886 (7), p. 102.

[3] American Naturalist, 1886, p. 1029.

measures of Pennsylvania (Plate XV), which is intermediate in the character of the anterior regions between Cephalaspis and Bothriolepis. The median orifice of the latter genus is present, and its middle portion is roofed by a plate. But this plate differs from that of Bothriolepis and Pterichthys, in being perforated by two orifices, which resemble in their position nostrils, while the lateral orifices have the position of the eyes of the Cephalaspididæ.

Under these circumstances the evidence in favor of the orifices in Bothriolepis being eyes, is stronger than that which points to its homology with the mouth of Tunicata. The structure of these primitive vertebrates strongly indicates the origin of lateral or paired eyes from a single median eye, such as is found in the Tunicata, and continues to point to the descent of Bothriolepis from those animals. Mycterops indicates a wider divergence than Bothriolepis; and Cephalaspis a still further stage of modification. Dr. Dollo, of Brussels, has expressed the view that the superior orifice of Pterichthys corresponds with the median eye of the Tunicata and the pineal eye of the Reptilia.

Of course, if the median eye of the Tunicata became specialized into the lateral eyes of higher vertebrates, it might seem improbable that it could be at the same time homologous, as there are no embryological reasons for refusing to believe (Spencer), with the pineal eye of the same forms, which possess also the lateral eyes. It may not be impossible, however, that this is really the case, and that the paired eyes, as well as the pineal eye, have been formed by evagination of differentiated parts of the Tunicate eye, so that the views of Lankester and Spencer may be both correct. The formation of the lens from two parts in the Tunicates, which precludes its correspondence with the pineal lens in Reptilia, probably has a significance in this connection, expressing the origin of the lateral eyes, while the retinal portion is homologous with the pineal retina.

In extinct American Batrachia the parietal foramen is wanting in Eryops and Zatrachys, and has not been observed in Trimerorhachis; but it is well developeds in Cricotus, the genus that leads probably to the Reptilia.

Among North American extinct reptiles I have described the characters [1] of the cast of the brain case in two widely distinct forms.

[1] Proceeds. Amer. Philos. Soc., 1886, p. 234.

These are Diadectes,[1] a Permian genus of Theromora, and Belodon, a Parasuchian crocodile. The former has an immense parietal foramen, while the latter has none. The general characters of the brain in Diadectes are as follows: The widest part is at the origin of the trigeminus nerve. Both the cerebellum and nesencephalon are flat, and simple. The hemispheres are narrower than the segments posterior to them, and of greater vertical diameter. The epiphysis is enormous, and its flattened posteriorly extending peduncle is very distinct. The olfactory lobes were apparently large, and had a greater transverse diameter than the hemispheres. The reduced diameter of the hemispheres is a character of fishes and Batrachia rather than of reptiles, but the thalami are also smaller than is the case in Batrachia. The small, flat cerebellum is rather batrachian than reptilian. (Plate XVI.)

There is some reason to suspect that the Diadectes relied exclusively on the pineal eye for the sense of sight. The species of the family were subterranean in their habits, since their humeri indicate great fossorial power, resembling those of the existing monotremes, and even the mole. The vertebræ are locked together with the hyposphen beside the usual articulations, and the arches of the neural canal form an uninterrupted roof from the skull to the tail, of extraordinary thickness and strength. That the species are not aquatic is rendered probable by the fact that the orbits do not look upwards. Their superior borders are, on the contrary, prominent and straight. Add to this fact the apparent absence of optic foramina, and the probability that the Diadectidæ were blind and subterranean in their habits becomes still stronger.

Belodon is a genus of reptiles which belongs to the sub-order Parasuchia of Huxley, which has been generally associated with the Crocodilia. It is characteristic of Triassic formations. Three species have been found in Europe, three in Eastern North America, and two in the Rocky Mountain region. One of the latter, *Belodon buceros* Cope, is represented in Plate XVII. It was about as large as the Gangetic gavial. As in Crocodilia generally there is no parietal foramen. Differently from crocodiles of later ages, the nostrils are posterior in position, and near the orbits, so that the nose might be plunged deeply beneath the surface of mud or water without inter-

[1] Loc. cit., 1887, p. 219.

EXPLANATIONS OF PLATES.

PLATE XV.

Fig. 1. Shell of *Bothriolepis canadensis* Whiteaves, from above. (From Whiteaves.)

Fig. 2. Anterior part of same, from below. (From Whiteaves.)

Fig. 3. Skull of *Mycterops ordinatus* Cope, from below, $\frac{2}{3}$ natural size.

PLATE XVI.

Cast of brain-case of Diadectes sp.

Figs. 1 and 2, cast of cranial cavity, natural size. As the basicranial axis is lost, the inferior outline posteriorly is provisional only.

Fig. 1, from above.

Fig. 2, from the left side.

Fig. 3, skull of *Diadectes phaseolinus*, from above.

The letters signify as follows: *m.*, medulla; *cb.*, cerebellum; *opl.*, optic lobe; *ep.*, epiphysis; *ppe.*, posterior process of epiphysis; *lf.*, lateral foramen; *h.*, region of cerebral hemispheres; *v.*, cast of vestibule.

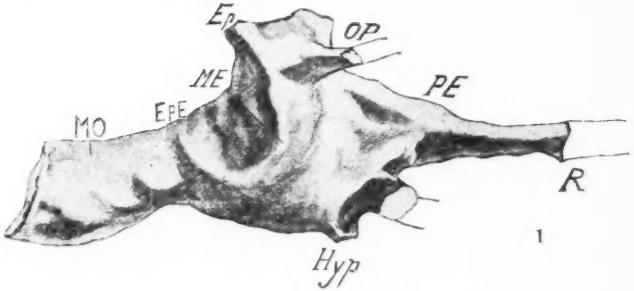
PLATE XVII.

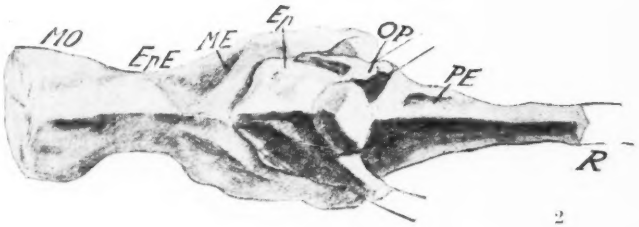
Cranium of *Belodon buceros* Cope, from Southwestern New Mexico, from which the following cast was taken; one-fourth natural size. Lateral, and one-half inferior and superior views.

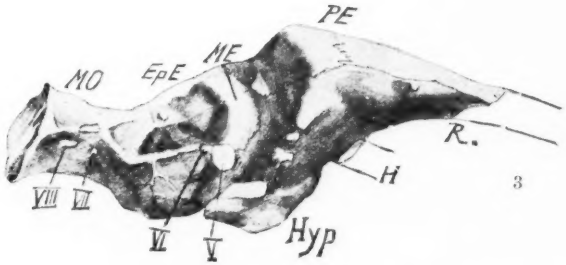
PLATE XVIII.

Cast of brain-cases of *Belodon buceros* and *Alligator mississippiensis*, natural size. Figs. 1–3. *Belodon buceros.* Figs. 4–5. *Alligator mississippiensis.* Fig. 1. Right side. Fig. 2. Superior surface. Fig. 3. Right side. RE. Rhinencephalon. PE. Prosencephalon. ME. Mesencephalon. Ep. E. Epencephalon (Cerebellum). MO. Medulla oblongata. Ep. Epiphysis. Hyp. Hypophysis. ii. Optic nerve; v. Trigeminus; vi. Abducens; vii. Facialis; viii. auditorius. Op. Orbitopineal process or nerve.

PLATE XVIII.







Cast of brain-cases of *Belodon buccros* and *Alligator mississippiensis*, natural size. Figs. 1–3. *Belodon buccros*. Figs. 4–5. *Alligator mississippiensis*. Fig. 1. Right side Fig. 2. Superior surface. Fig. 3. Right side.

fering with the respiration. The characters of the brain are as follows:

The first point which arrests the attention in making a comparison with Diadectes is the similarly huge size of the epiphysis in the two types. A foramen on each side of the base of the epiphysis in the Diadectes gave exit to a process similar to that which enters the orbitopineal canal in the Belodon, and which I called the lateral process of the epiphysis in the latter. Plate XVIII, figs. 1–3, 1 f). The processes are probably homologous in the two genera, but in the Belodon they extend through the posterior wall of the orbit, filling a large canal. There is little resemblance between the two brains in other respects, but they agree in the small size of the prosencephalon, and in the complete enclosure of the rhinencephalon by osseous walls. In the Diadectes there is no optic foramen, but a huge trigeminus; in Belodon, an optic foramen, and a very small trigeminus.

The presence of such a huge epiphysis in the Belodon, as compared with its very small size in modern crocodiles, is a point of much interest, and points to its inheritance from the reptiles of the Permian. But if, as is probable, it contained the pineal eye, the latter could not receive light directly from above, since the parietal foramen is wanting. The presence of a communication with the orbit becomes interesting in this connection. A minute foramen passes from the base of the rhinencephalon into the orbit in the alligator, but the homology with the *canalis orbitopinealis* of Belodon is by no means made out. The *nervus orbitopinealis* may have supplied the lack of light due to the closure of the parietal foramen, but in what way we are left to conjecture.

The equality of size of the brain of the Belodon to that of the existing alligator is a point of interest.

The Belodons were probably aquatic reptiles, living on the shores of estuaries like modern crocodiles, and were of carnivorous habits.

EDITORS' TABLE.

EDITORS: E. D. COPE AND J. S. KINGSLEY.

Economy pushed to its extreme becomes niggardliness. The appropriation for a Governmental Zoological Garden at the Capital has been defeated in the House of Representatives, not because of any objection to the proposition, to the location, to the site, nor to the necessity, but solely because of the money it would cost. It was simply the wail of a miser. The benefit from, in fact necessity for, a Governmental Zoological Garden was conceded. The time and opportunity were *apropos*. It was not denied that the management was in proper hands. No argument was made against the project save that it would cost money, and this was played *ad nauseam*. The opponents of the project raised their voices and fairly wept over this great expenditure of money.

We attempt no homily on the duties of a legislator, nor to explain how it is sometimes as much his duty to spend money as it is at others to save it. The United States, with a greater territory, greater riches, and with undoubtedly greater opportunities, is behind third and fourth-rate kingdoms in the matter of zoological gardens. The *Materiaux pour l'historie de l'Homme* for August has an article entitled "Extinction of the Buffalo," in which it notices a capture or massacre, in the Territory of Arizona, of a herd of buffalo (*Bos americanus*), and says, "The race is now practically extinct." It laments that these are not the only zoologic forms in America which have become so, and closes, "The Republic of the United States of America is less careful of its opportunities, and pays less regard to its duty to science than does the Russian Empire, where the European bison of pre-historic times lives under the protection of the Czar."

If the two or three gentleman who led the opposition, and the fifty-six members who voted with them, shall continue the defeat of the project, and thus the buffalo become an extinct animal, with others now threatened, the descendants of these gentlemen will have little cause for pride in this act of their ancestors.

There never will be a time when this project can be carried out

more opportunely than at the present. Each year that it is postponed increases the expense. Many people stand ready now to aid it with contributions of animals. If a place were but provided in which the animals could be kept and cared for, the Garden would soon fill up. But with the passage of time these opportunities will also pass, and the difficulties and expense correspondingly increase.

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GENERAL NOTES.

GEOLOGY AND PALÆONTOLOGY.

VARIATIONS OF GRAVITY IN APPROACHING THE CENTRE OF ANY COSMIC SPHERE WHATEVER.—First, within a hypothetical hollow sphere, the solid shell of which is, in all parts, of equal density and of equal thickness, gravity at every point is in absolute equilibration. This results from two laws. First, gravity, relative to the same kind of matter, varies directly as the quantities. Let Q equal one quantity and q equal another; and G equal the gravity of Q, and g equal the gravity of q: then will $Q : q :: G : g$, and there results $Q \times g = G \times q$, or $g = \frac{G \times q}{Q}$.

Now, if, in our hypothetical hollow sphere, we assume any point whatever, and draw a line through that point to the nearest and most distant points of the shell, this line will be a straight line, and the longest that can be drawn in the sphere; hence it passes through the centre, and is the diameter. Now, pass a plane through this assumed point and perpendicular to the diameter, cutting the shell into two segments, corresponding to the two segments of the diameter made by the assumed point.

Let R equal one segment of the diameter, and r equal the other; let Q equal the segment of the shell corresponding to R, and q equal the segment corresponding to r: then, since, by hypothesis, the density and thickness are everywhere equal, there results $Q : q :: R^2 : r^2$, and $Q\ r^2 = q\ R^2$; but gravity varies in proportion to the duplicate ratios of the reciprocals of distance, R and r. Let G represent the gravity of the segment $R^2 \times q$, and g represent the gravity of segment $r^2\ Q$, at the assumed point, then we have $G : g :: \frac{1}{R^2\ q} : \frac{1}{r^2\ Q}$; therefore, $G\ R^2\ q = g\ r^2\ Q$. Now, since $Q\ r^2 = q\ R^2$, $G = g$: *i.e.*, gravity, at any point whatever, in this hollow shell, is in absolute equilibration. Hence, in approaching the centre of any cosmic sphere, any point is in equilibration, relative to all the external shell; and gravity at any point is determined by the mass of the internal sphere, measuring from the point assumed to the centre for the radius of the internal sphere.

But the masses of spheres are directly proportioned to the triplicate ratios of their radii. Let R equal the radius of the cosmic sphere, and r equal the distance from the point assumed to the centre, *i. e.*, radius of the inner sphere. Let G equal the gravity on the surface of our cosmic sphere, and g equal the gravity at the point assumed: then will result $G : g :: R^3 : r^3$; $g = \frac{G\ r^3}{R^3}$. At the centre r equals 0 and $g = 0$. They vanish together.

As a matter of fact, however, this proportion and equation are true for two points only: viz., at the surface, when $R = r$, and at the centre, when $r = 0$. Why? Because the density varies with the pressure, in the first place. Though the weight, *i. e.*, the gravity, relative to that sphere alone, is greatest at the surface, in the case of any given quantity of matter, yet, under the superincumbent pressure, the density of the inner sphere, composed of the same matter, is greater than that of the entire sphere.

Again, the heavier matter, *i.e.*, the matter of the highest specific gravity, during the process of free centralization, naturally forms the nucleus of the sphere, throwing the lighter materials to the surface, as we see in case of our earth. Thus, for two reasons, the

centres of all cosmic spheres are of higher specific gravity than the surfaces. On the contrary, after solidification has taken place, by virtue of thermal radiation into the infinite of space, the high degree of internal heat tends, very considerably, to diminish the density of the interior.

The complexity of this problem is not amenable to mathematic resolution. Even the elastic resiliency of the most persistent gases increases more rapidly than any assumed amount of pressure. Thus, if the pressure increases as the natural series 1, 2, 3, 4, etc., the elastic resilience is such that the resulting volumes are not $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., nor anything like it, except in the very lowest of the series. Still we are warranted in all cases in saying that the greater the pressure the greater the density for the same kind of matter.

Now, a few words on the formation of a solid crust over a molten sphere are entirely pertinent. It has been held by some authors that no crust can form over such a sphere; for, say they, *when the surface cools it is heavier than the molten mass within, and must necessarily sink; so that the centre would become solid first.* First, here is a palpable *reductio ad absurdam;* for this would necessarily result in cooling so as to solidify at the centre first. Can any rational mind accept this absurdity?

Second, ejected lavas always cool on the surface first, while yet the deeper portions are molten even so as to flow long after a solid crust has been formed. Thus does direct observation show the falsity of their hypothesis. No more need be said on that score.

Third, these authors neglect the fact that the lighter materials lie like a thick blanket around the outside of the sphere; and though they were to become frozen even, they could never sink into the molten heavier matter. Cold iron can not sink in molten gold. Cold silicon can not sink in molten iron. Yet, all the lighter materials are on and form the outside of earth, and of every other sphere where they exist. Unless there may exist a cosmic sphere of pure gold or pure platinum, or something of that kind, their hypothesis can never be realized.

Fourth, these lighter materials are highly non-conductive to heat, and hence husband the internal heat most providentially; so that earth will continue to have an internal heated core for raising mountains, continents, islands, etc., eons to come, as it thus far has had during eons past.

Fifth, the dream of those other philosophers, that all the waters of all the oceans will disappear to the centre of earth, cannot be realized, unless the outer non-conductive materials are in excess of the heavier central materials, which the higher mean gravity of earth seems to contradict.

Sixth, this fact of heavier central materials insures the molten condition of a portion of the centre, in spite of all contrary hypo-

theses. Through these heavier materials conduction is rapid, and the maximum is easily maintained. Mark! I say a portion of the centre, for the centre is unquestionably solid, as a resultant of pressure, the temperature being the maximum attained at the point of liquefaction. As the inner portion consists of the heavier materials, which are also far better conductors of heat, and rendered still better conductors under the immense pressure of the superincumbent materials, this solid nucleus will maintain, by conduction, this maximum temperature throughout. Finally, it may not be void of all interest to take a very brief view of earth's outer envelop.

The entire outer shell, as all know, consists mainly of two persistent gases—oxygen and nitrogen; oxygen, a constantly active, ever varying, yet constantly nearly the same in proportion; and nitrogen, a neutral dilutent for the active oxygen. With these two are mingled a few other substances, most conspicuous of which is watery vapor.

Next is a shell—a little broken—of water. This is followed, in the descending order, by a shell of mingled substances, the common rock materials. These are very poor conductors of heat. The lighter of these materials do not form a very thick mass. As the entire mass of earth, including all these, has a much higher specific gravity than any of these, it follows that heavier materials soon begin to take the place of these; nevertheless, this outer envelop must be sufficient to protect the heated nucleus, and volcanic emissions show that their seat is not below this outer shell, but in it. —*Ira Sayles, Ithaca, N. Y.*, March 12, 1888.

(To be continued.)

The Attachment of Platycerata to Fossil Crinoids has been long known, but the hitherto extreme rarity of illustrative specimens has necessarily occasioned only brief explanatory remarks. Inasmuch as the gasteropod shell was invariably situated on the crinoidal vault, and covering the ventral opening, which was erroneously regarded as the mouth of the crinoid, conclusive evidence of the carnivorous habits of the crinoideans was thought to be established. Other explanations were from time to time offered, but for the most part they were also fallacious, and originated in wrong conceptions relative to the true functions of certain structures peculiar to the group of echinoderms. Opportunity has recently been offered for the examination of an extensive series of palæocrinoids with attached Platycerata, embracing numerous specimens of the following species: *Ollacrinus tuberosus* Lyon and C., *O. typus* Hall, *Physetocrinus ventricosus* Hall, *Strotocrinus regalis* Hall, *Dorycrinus immaturus* Wachsmuth and Springer, *Marsupiocrinus cœlatus* Phil-

lips, *Eucladocrinus millebranchiatus* Wachs. and Sp., *Platycrinus hemisphæricus* M. and W., *Arthroacantha punctobrachiata* Williams, *Pterotocrinus acutus* Weth., *P. bifurcatus* Weth., *P. spatulatus* Weth., *Cromyocrinus simplex* Trauts., *Scaphiocrinus sp. und.* and *Actinocrinus verrucosus* Hall. It will be observed that in all the above species, with two exceptions, the vault is more or less depressed or nearly flat, with a simple anal opening, while in the last species mentioned the anal aperture is at the extremity of a prolonged anal tube—the so-called "proboscis"—but in this single instance the tube appeared to be injured, and probably has a second opening at the base. In every example, whether attached to the vault, as in the majority of the genera, or to the side of the calyx, as in Platycrinus, the molluscan shell is situated over the anal opening.

Summing up the predominant physiological and structural features suggested by recent investigations, it appears: (1) that the Platyceras was attached to the crinoid for a considerable length of time, and very probably for life, as is evidenced by the margin of the gastropod shell, corresponding exactly to the irregularities of the crinoidal surface—first suggested by Meek and Worthen; (2) that the anterior portion of the shell is always directly over the anal aperture of the crinoid, and that as growth in the shell continues the posterior margin is removed farther and farther from the vault opening, as is shown by the shallow concentric channels made by the margin of the shell in the vaults of Strotocrinus and Physetocrinus; (3) that the nourishment of the mollusc must have been derived chiefly from the excrementitious matter from the crinoid, though the gasteropod may have subsisted also on animalcules and microscopic plants, as in the case of the living representatives of the closely allied genus Capulus; (4) that the shape of the shell aperture and its marginal configuration were dependent entirely upon the surface of attachment, and hence are of small classificatory value; and (5) that the entire form of the shell was determined to a greater or lesser extent by the surface upon which the gasteropod was stationed.

The species of Platyceras in which the sedentary habits are positively known from the attachment of the gasteropod shells to crinoids are: *P. equilaterum* Hall, *P. infundibulum* M. and W., *P. parasiticus* Trauts., *P. erectum* Hall, *P. formosum* Keyes, *P. chesterense* M. and W., *P. dumosum* Conrad, and several undetermined species.—*Charles R. Keyes.*

GLYPTOCEPHALUS NOT IDENTICAL WITH BUCKLANDIUM.—In the AMERICAN NATURALIST for May and September, 1888 (Vol. XXII., pp. 448, 828), I have used the name *Bucklandium* (Kœnig) as a substitute for *Glyptocephalus* of Agassiz (1843), the latter name

having been previously given to a well-marked existing genus of Pleuronectids by Gottsche (1835). I did this, as indicated in my communication (p. 828), solely on the authority of Pictet, who believed that the *Bucklandium* was the same as *Glyptocephalus* Agass.,[1] the work of Kœnig not being accessible to me at the time, and Prof. Pictet being recognized as a special authority on eocene fishes. But in the *Geological Magazine* for Oct., 1888 (p. 471), and also in *The Annals and Magazine of Nat. History* for Oct. (6 ser., v. II, p. 355), Mr. A. Smith Woodward, after an examination of the type of *Bucklandium diluvii*, "determined that it is truly the imperfect head and pectoral arch of a Siluroid." Incredible as such a malidentification on the part of Pictet must appear, I presume the determination of Mr. Woodward must be accepted, and, at any rate, that the name *Bucklandium* has nothing to do with *Glyptocephalus*. Consequently, a new name must be provided for *Glyptocephalus* Agass. *Glyptocara*, having the same meaning, may be employed. —*Theo Gill.*

Dr. C. A. White, of the United States Geological Survey, writes the senior editor as follows:—"I have just returned from Texas. I went to Baylor, Archer and Wichita counties, and found that Mr. Cummins was entirely correct in his reported discovery of Mesozoic and Palæozoic types of invertebrates commingled in one and the same layer of the Permian. I went with him to his localities, and collected with my own hands a good lot of the fossils. I shall support your published opinion—or rather determination—as to the Permian age of the formation."

THE NOMENCLATURE OF THE MAMMALIAN MOLAR CUSPS.—Every fresh discovery among the primitive mammals tends to confirm the theory that the evolution of the molar crowns has been, in a succession of stages, beginning with the single reptilian cone, the *homodont* type of Rütimeyer (*Haplodont* Cope). Comparative anatomy and the palæontological record combine to demonstrate this proposition for all orders of mammals excepting the Monotremes, Multituberculates and Edentates—the history of the teeth of the former classes is incomplete. Our knowledge of the edentates leaves it uncertain whether the molar crowns are in a primitive or degenerate condition; we know that they once possessed enamel, but the analogical degeneration of the molar crowns among the cetacea from a complex to a primitive type makes any conjecture as to the crowns of the primitive edentates very doubtful. Excluding the representatives of the Multituberculata, Cope has shown

[1] Je crois que c'est [*i.e.*, "*Glyptocephalus radiatus* Agass."] la même espèce que celle qu'il a figurée dans les *Icones sectiles*, pl. 8, sous le nom de Bucklandium. Voyez [Traité de Paléontologie par Pictet], t. I., p. 144, et t. II., p. 66 [et p. 123].

that the tritubercular stage, in one form or other, is universal among the known lower Eocene Mammalia. In a recent memoir, I showed that a large proportion of the Mammalia of the Mesozoic period, again excluding the Multituberculates, were in the line of *tritubercuły*, and a renewed examination of the English types *removes every one of the apparent exceptions* to this law. Among the American Jurassic types there are still several apparent exceptions.

In view of the evidence for the almost universal presence of the tritubercular stage in the present or past history of the upper and lower molars, I have already advocated a distinct nomenclature for the different cusps which compose this molar and its derivatives, up to the stage of the acquisition of six tubercles in the upper molars and five in the lower. This is the final stage in which the tubercles reman distinct. The nomenclature now in general use is based, for the most part, upon the secondary or acquired position, and in no instance, so far as I know, upon the demonstrable homologies of the cusps in the upper and lower jaws. Compare for example, the molars of *Mioclænus* and *Hyopsodus*. By those familiar with Cope's writings upon this subject, it will be recognized at once that the antero-internal cusp of the lower molar of *Mioclænus* is not homologous with the antero-internal cusp of the upper molar of the same genus, nor is it homologous with the antero-internal cusp of the lower molar of *Hyopsodus*.

The nomenclature proposed is based upon the fact that the cusps composing the main triangles are homologous with each other and that some of the cusps superadded to these to form respectively the six and five tubercled molars, have probably originated in a similar manner. The terms for the three main cusps are selected to indicate, as far as possible, the primitive position and the order of evolution. The lower molar cusps are arbitrarily distinguished from those of the upper molars by the termination *id*.

Terms proposed.		*Terms now in use.*	
Up. Molars.	*Low. Molars.*	*Upper Molars.*	*Lower Molars.*
Protocone.	Protoconid.	Antero-internal cusp.	Antero external cusp.
Paracone.	Paraconid.	Antero-external "	Antero-internal " or 5th cusp.
Metacone.	Metaconid.	Postero-external "	Postero-internal " or intermediate "
Hypocone.	Hypoconid.	Postero-internal " or 6th cusp.	Postero-external "
Protoconule.		Anterior-interme diate cusp.	
Metaconule.		Posterior-interme-diate.	
	Epiconid.....	.....	..Postero-internal cusp.

This note is from an abstract of a paper presented to the British Association at Bath upon the Evolution of the Mammalian Molar

teeth. The full paper will appear in the next number of the NATURALIST. In the meantime I will be glad to receive suggestions or criticisms upon the above terms.—*Henry F. Osborn.*

MINERALOGY AND PETROGRAPHY.[1]

PETROGRAPHICAL NEWS.—The basaltic rocks of Alsace, according to Linck,[2] embrace feldspathic and non-feldspathic varieties. Of the latter a limburgite from Reichenweiler contains a glassy base, which deports itself towards reagents like nepheline, a fact which would cause the rock strictly to be classed among the nepheline basalts. Its olivine yields upon analysis:—

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	Na_2O
41.53	2.33	0.58	10.27	43.60	1.69,

indicating a replacement of part of the magnesium of the typical molecule by aluminium and sodium. Olivine concretions occurring in this rock consist of olivine, bronzite and a bottle-green augite containing 2.64 per cent. of K_2O and 2.41 per cent. of Na_2O.—Brief notes on the rocks of Fernando Noronha, an island in the Atlantic about two hundred miles north-east of Cape St. Roque, Brazil, are communicated from the laboratory of the Johns Hopkins University by Mr. Gill.[3] The rocks described are phonolites, from conical hills similar to those in the Hegau in Baden, nepheline-basanites and basalts, nephelinite, and finally basalt glass. An extended petrographical study of these in all their different varieties will be published later.—Although the rocks of the Bohemian Mittelgebirge have been made the subjects of study by several petrographers, Hibsch[4] finds something new to say of them in a late article in *Tschermak's Mittheilungen*. The trachytes of the region are younger than the phonolites or the basalts and occur in but a few localities. Their porphyritic sanidines possess a rounded outline and are fringed with a rim of newly formed secondary feldspathic substance. Many of the phonolites contain a large amount of plagioclase, and have besides a trachytic habit. In their cavities is often noticed quite an interesting development of secondary albite. Little crystals of this mineral extend out from the sides of the cavity and penetrate into a mass of analcite, which, together

[1] Edited by Dr. W. S. Bayley, Colby University, Waterville, Me.
[2] Mitth. d. Comm. f. d. Geol. Landesunters, von Elo.-Lothr., 1887, i., p. 49.
[3] Johns Hopkins Univ. Circulars, No. 65, April, 1888, p. 71.
[4] Min. u. Petrog. Mitth., 1887, p. 232.

with chabasite, has resulted from the alteration of the plagioclase. —In Blum's "Pseudomorphosen"[1] mention is made of a granite at Vordorf in the Fichtelgebirge, in which the flesh-red orthoclase is partially altered into epidote. Sandberger,[2] who has found blocks of the same rock, states that the epidote is more likely an alteration product of hornblende or augite, as it is associated with asbestus, while the red orthoclase is still fresh.—A grammatite rock occurs,[3] interstratified with phyllite, in the Bohemian Fichtelgebirge, between Klein-Wenden and Sichersreuth.—The third paper on the rocks of the Cortlandt Series, in the Hudson river, embraces[4] the treatment of the gabbros and diorites associated with the peridotites and norites which have been described in another place.[5] The gabbros present no peculiar features other than the granulation of some of their constituents. Two types of diorite are distinguished. One, containing brown hornblende, tends to pass into gabbro, norite, or hornblendite. The other, containing green hornlende, is closely related to mica-bearing rocks. The mica-diorites (Dana's soda-granites) are essentially coarse-grained aggregates of plagioclase and biotite, with often a little orthoclase and quartz, and sometimes garnet as a metamorphic mineral. The plagioclase has a specific gravity between 2.67 and 2.65, and is sometimes twinned, while at other times it is entirely free from twinning lamellæ. The most noticeable feature in the rock is the occurrence in it of a pale green non-pleochroic epidote, which appears to be original. The mineral is generally without terminations. It is strongly corroded on its edges as if eaten into by a liquid magma. The paper closes with a graphic representation of the close relations, which the author, Dr. Williams, has found to exist between the various eruptive members of this series.

Mineralogical News.—In Douglas Co., Oregon, is a bed of *nickel silicate*, resembling garnierite, whose origin has been determined with some degree of certainty by Prof. Clarke.[6] A pure specimen of the mineral was found to have the composition:—

TiO	MgO	SiO_2	$Al_2O_3+Fe_2O_3$	Loss on ign.	Loss at 110°
27.57	10.56	44.73	1.18	6.99	8.87

The country rock associated with this mineral is a peridotite whose olivine contains .26 per cent. of nickel oxide. This rock was examined by Mr. Dieles, and was found to be penetrated by cracks filled with serpentine and quartz. The nickel mineral, wherever it

[1] iii., p. 120.
[2] Neues. Jahrb. f. Min., etc., 1888, i., p. 208.
[3] Sandberger: Neues Jahrb. f. Min., etc., 1888, ii., p. 202.
[4] Amer. Jour. Sci., June, 1888, xxxv., p. 438.
[5] Amer. Naturalist, June, 1887, p. 568.
[6] Amer. Jour. Sci., xxxv., 1888, p. 483.

occurs,is always associated with these alteration products. It occurs in the serpentine, which is directly connected with the grains of olivine from which it has been derived. There is every reason to believe that the nickel silicate came from the same source. A study of the Webster Co., N. C., and the New Caledonia nickel deposits indicate the same origin for the ores at these places.—A feldspar from Kilima-njaro, similar to that from the rhombic porphyry of Christiania, has been analyzed by Fletcher.[1] Its composition is:—

SiO_2	Al_2O_3	CaO	Na_2O	K_2O
62.17	23.52	2.90	6.80	4.61,

corresponding to a mixture of the anorthite, microcline and albite molecules in the proportions $An, Or_{.94}, Al_{2.11}$. The extinction on the clinopinacoid is about 4° 20′. On the basal plane it is parallel to the clinopinacoid cleavage. In sections cut parallel to the orthopinacoid the microcline structure is visible.—Sandberger[2] calls attention to the properties of the carbonaceous material in the crystalline limestone of Wunsiedel in the Fichtelgebirge, as those of an amorphous substance corresponding to the graphitoid of Inostranzeff[3] and Sauer.[4] The hardness of the mineral is 3 and the specific gravity 2.207. It yields when burned 1.78 per cent. of ash.—A new analysis of *spodumene* from Brazil leads Jannasch[5] to the results reached by other analysts, and affirms the correctness of the formula $(Li.\ Na)_2\ Al_2\ (SiO_3)_4$.—Brief notes on the six iron sulphates, *coquimbite, copiapite, quenstedtite, bückingite, stypticite* and *halotrichite*, from Chili, are communicated by Linck[6] in a letter to the *Neues Jahrbuch.*

Morphological and Physical Mineralogy.—Since almost all of our knowledge of the morphological properties of *markasite* depend principally upon the measurements of Hausmann and Sadebeck, and since these mineralogists disagree in their results, Gehmacher[7] has thought it worth while to measure the crystals in his possession, and from these measurements to recalculate the planes occurring in them. He finds the axial ratio to be: .7623 : 1 : 1.2167. The formulas of the different planes are determined, and other observations are made which indicate a monoclinic symmetry for the mineral.—Zepharovich's[8] measurements of *trona* crystals from Lake Lagunillas, Venezuela, show their axial relation to be:

[1] Min. Magazine, July, 1887, and Zeits. f. Kryst. xiii., '87, p. 384.
[2] Neues Jahrb. f. Min., etc., 1888, i., p. 200.
[3] Neues Jahrb. f. Miner., etc., 1880, i., p. 97.
[4] Zeits. d. d. Geol. Zeits., xxxvii., p. 441.
[5] Neues Jahrb. f. Min., etc., 1888, i., p. 196.
[6] Neues Jahrb., f. Min., etc., 1888, i., p. 213.
[7] Zeits. f. Kryst., xiii., 1887, p. 242.
[8] Ib., xiii., 1887, p. 135.

2.8459 : 1 : 2.9696. $\beta = 77° 23'$. Their composition corresponds to that of the same mineral from other localities.—Very pure *idrialite* ($C_{80}H_{36}O_2$), crystals from Idria in Krain, consist of small plates bounded on two sides by parallel planes. The extinction against one of these sides is 5° 33′, and the optical angle of the mineral, measured in oil, is $2H = 101° 20'$. The interference figure is that of a biaxial crystal, with the bisectrix perpendicular to the surfaces of the plate.—A great many observations have been made by Niedmann[1] upon *barite* in order to determine the relations between the elasticity and the other physical properties of the mineral. He finds the direction of greatest elasticity to be perpendicular to the plane of easiest cleavage. The shape of the curve representing the relative values of the coefficients of elasticity for any given plane, corresponds in all cases to the symmetry of the orthorhombic system.

Miscellaneous.—In a late paper Dr. Cohen[2] discusses critically the arguments in favor of the chemical theory of deposition for gold in placers, and also those in favor of its mechanical origin. He gives the main facts bearing on the subject, and shows that some of those which have always been cited as favoring the chemical theory, are of doubtful existence. It has been stated, for instance, that placer gold always contains less silver than vein gold from the same region. Analyses of specimens from Buttons Creek, in the South African gold-fields, however, prove that this is not always the case. Dr. Cohen's results are:—

	Au	Ag	Cu	Insol.
Vein gold	94.48	5.16	.25	.02
Placer gold	91.38	6.49	.09	.78
	95.02	4.60	.11	.07

He thinks that whereas placer gold, for the most part, is derived by the breaking down of gold veins, there is occasionally in addition a deposition of the metal from its solutions. This, however, he regards as playing but a subordinate rôle in the formation of placer gold.—A meteoric stone,[3] found in the San Emigdio mountains in California, is composed of chondri of olivine and anstatite, imbedded in a base composed of the same minerals in a fragmental condition. Nickeliferous iron constitutes 6·21 per cent. of the stone. It occurs in lumps and masses, often surrounding the chondri. An analysis of the metallic portion yielded 11.27 per cent. of nickel.

[1] Ib., xiii., 1887, p. 362.
[2] Mitth. d. naturw. Ver. f. Neuvorpom. u. Rügen, 19 Jahrg., 1887.
[3] Merrill: Am. Jour. Sci., June, 1888, p. 490.

ZOOLOGY.

CELL-DIVISION.—The following abstract of recent researches on cell-division is taken from the *Journal of the Royal Microscopical Society.*—Herr T. Boveri believes that the course of karyokinetic division may be generally described in the following terms:—The chromatic nuclear material becomes collected together with a definite number of isolated pieces of a form characteristic of the kind of cell—the chromatic elements; an achromatic filamentar figure is formed in the two poles, either from the substance of the nucleus or from that of the cell. The chromatic elements, so far as their number, form and size allow it, are deposited in the equatorial plane of the achromatic figure; the chromatic elements divide into two halves, one of which makes its way toward either pole; the daughter elements break up in the framework of the new nuclei.

In the ova of *Ascaris lumbricoides* the germinal vesicle has, in the earliest stage, the typical structure of the resting nucleus, and we are justified in supposing that the chromatic elements arise from the framework in exactly the same way as in the other cases, though the details cannot certainly be made out in consequence of the small size of the object. The arrangement of the elements in an equatorial plate, their transverse division, and the formation of daughter-plates, are effected in just the same way as they are now known to be in other cases, and especially in the ova of arthropods. The only point of difference is the relation of the daughter-elements, which remain in the egg after the expulsion of the first polar globule, for these remain isolated, and are so the direct mother-elements of the next spindle.

In the germinal vesicle of the ovum of *Ascaris megalocephala* (Carnoy's type), two independent portions of chromatin are found in the earliest known stage. Though nothing is certainly known of their mode of formation, it may be assumed that they are derived from a typical nuclear framework. This conversion, however, of the reticulum into the chromatic elements, which in other cells and in some ova (*A. lumbricoides*) directly precedes division, appears, in most eggs, to take a long time. The important difference in the eggs of the type of Van Beneden is that there is but one chromatic element; this seems to be unique.

There are many reasons for supposing that the division of the chromatic elements sometimes happens at a time when there is no indication of the achromatic figures of division. The most striking of these cases has been lately described by Flemming. Similar phenomena have been observed by the author in the eggs of Ascaris. In the germinal vesicle of *Ascaris lumbricoides* the

twenty-four rods exhibit the most distinct transverse division long before the germinal vesicle begins to be converted into the spindle.

After considering several cases in different forms the author expresses his belief that they form parts of a series in the degeneration of the process of nuclear and cellular division. In the case of *Corydalis cava*, described by Strasburger, the process is least rudimentary; two typical daughter-nuclei arise, but these again fuse into a single nucleus; in Thysanozoon and *A. megalocephala* daughter-stars or plates are formed, but at once pass into a resting nucleus. In the cells of Flemming and Carnoy there is a division of the chromatic elements, but no arrangement in two groups.

Herr Boveri suggests that in the parthenogenetic eggs described by Weismann as having only one polar globule, we have to do with the same process as in the eggs of Ascarids; there are two divisions, but the second is limited to division of the chromatic elements. If this be so, the parthenogenetic development is not to be regarded as dependent on the suppression of the development of the second polar globule, but by its retention in the egg and the fusion of its nucleus with the ovarian nucleus. The second polar globule may thus be regarded as playing the part of the spermatozoon, and it may be said that parthenogenesis is due to fertilization by the second polar globule.

In the achromatic nuclear figure the mode of origin of the spindle, and the complete want of polar rays are of significance. The often discussed question whether the nuclear spindle is derived from the substance of the nucleus, or of the cell, may, in the case of Carnoy's type of *Ascaris megalocephala*, be certainly decided in favor of the former.

Nervous System of the Starfish.—Dr. Carl F. Jickeli recognizes (*Zool. Anzeiger*, 1888, p. 339) four elements in the nervous system of the starfishes:—(1) The ambulacral nervous system; (2) the sub-epithelial plexus of the surface of the body, described by Romanes and Ewart; (3) the paired thickenings of the walls of the perihæmal system described by Lange; and (4) a visceral system. The sub-epithelial plexus is connected with the ambulacral system. Lange's nerves consist of three layers; (*a*) a delicate flattened epithelium lining the perihæmal space; (*b*) large ganglion cells, the processes of which form nerve fibres; and (*c*) a connective-tissue layer which forms a partition between Lange's and the ambulacral nerves. Jickeli's visceral system consists of a layer of fine fibres containing stellate cells at the base of the epithelium of the digestive tract. This system is best developed in the anal region of *Astropecten andromeda*.

STIZOSTEDIUM IN THE BASIN OF THE CONNECTICUT.—I had the pleasure of announcing in the AMERICAN NATURALIST for October, 1887, the discovery of a specimen of *Stizostedium vitreum* at Cromwell, Conn., in a tributary of the Connecticut River. This is, so far as I am aware, the only recorded instance of the occurrence of the species in any of the rivers of the Atlantic coast between the St. Lawrence and the Susquehanna. It may be worth while to mention that in August, 1888, another specimen of the same species was taken very near the same locality. The second specimen, like the first, is a small one, each of them measuring about twelve inches in length. Both specimens are preserved in the Museum of Wesleyan University.—*William North Rice, Wesleyan University, Middletown, Conn.*

DESCRIPTION OF A NEW SPECIES OF MEADOW MOUSE FROM THE BLACK HILLS OF DAKOTA.—In the higher parts of the Black Hills there lives a species of Arvicola resembling our eastern Meadow Mouse (*A. riparius*) in size and coloration, but differing from it strikingly in the possession of a very long tail and very large ears. Two specimens were collected in some brush land bordering a creek in the vicinity of Custer, Dakota, by Mr. Vernon Bailey, in July last. Examination of their teeth shows them to belong to the subgenus Myonomes. The species has no nearer relative than *Arvicola townsendi*, from which it differs in relative proportions and in other particulars. It may be known by the following diagnosis:

ARVICOLA (MYONOMES) LONGICAUDUS sp. nov.

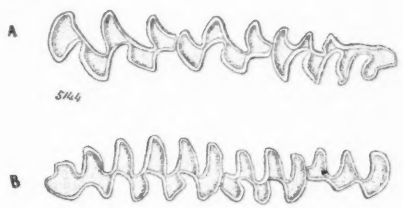
Long-tailed Arvicola.

Type No. $\frac{4509}{5144}$, fem. ad., Merriam Collection. From Custer (in the Black Hills), Dakota, July 19, 1887. Vernon Bailey.

Description of type.—Size about that of *A. riparius*. Ears very large, suborbicular, with a large antitragus capable of completely closing the meatus; tail very long, relatively longer than that of any heretofore described species of the genus; color much as in *A. riparius;* sides and upper parts bister, more or less grizzled, with a faint tinge of rusty along the middle of the back; under parts whitish, the plumbeus basal portion of the fur showing through. There is no sharp line of demarcation between the color of the belly and that of the sides; the tail is slightly paler below than above, but lacks a distinct line of demarcation.

Measurements (taken in the flesh): total length, 185 mm.; tail, 65 mm.; hind foot, 21 mm. Ear (measured from the dry skin):

height from anterior base, 14 mm.; from crown, 8 mm.; breadth, 13 mm. Another specimen, also a female, taken at the same locality, July 13, 1888, agrees with the foregoing in size and coloration. It measured in the flesh: length, 184 mm.; tail, 61 mm.: hind foot, 22 mm.



Molar teeth of Arvicola longicaudus ♀
A. Left upper series B Left lower series

Dental characters.—A glance at the accompanying drawing of the crowns of the molar teeth shows that *Arvicola longicaudus* has the back upper molar of Myonomes. The middle upper molar, however, lacks any trace of the postero-internal loop or spur supposed to be characteristic of this subgenus, and the lower teeth present several peculiarities not mentioned in any description or drawing heretofore published.—*Dr. C. Hart Merriam.*

Zoological News.—General.—The zoological papers in the *Journal of the Elisha Mitchell Scientific Society* for 1888 are: "A List of Fishes in the Museum of the University of North Carolina," by V. S. Bryant; "List of the Butterflies collected at Chapel Hill, N. C.," by A. Braswell; "Aquatic Respiration in the Muskrat," by W. L. Spoon; "New Instances of Protective Resemblance in Spiders," and "Notes on the Tube-inhabiting Spider, *Lycosa fatifera*," by G. F. Atkinson.

Protozoa.—The genus Gromia is usually regarded as an inhabitant of moist earth, but Dr. H. Blanc describes a species which he considers as a member of the genus from the ooze at the bottom of Lake Geneva. His paper, which occurs in the *Recueil Zool. Suisse* (Vol. IV.), is illustrated by a plate.

Worms.—Dr. Edward Tuckerman records (*Zool. Anzeiger*, No. 287) a second specimen of *Tænia saginata*, which was larger than the former specimen (Am. Nat., p. 360, 1888), measuring 8.253 metres. This latter specimen presents several interesting anomalies of structure. In the same number Dr. Ed-

ouard Brandt records two instances of *Tænia cucumerina* in the human body.

Dr. A. C. Stokes describes two new North American Oligochæte worms (*The Microscope*, viii., 1888), *Ælosoma distichum* and *Pristina flavifrons*, and Gustav Eisen characterizes a new genus of the same group (*Mem. Cal. Acad.*, ii., 1888) under the name *Sutroa rostrata*.

Criodrilus lacuum is made the subject of an extensive anatomical monograph by A. Collier in the *Zeitsch Wiss. Zoologie*, Bd. xlvi., 1888.

Molluscs.—The crystalline style is a peculiar structure found in a pocket developed from the stomach of certain lamellibranch molluscs. Many theories have been advanced as to its nature and physiological functions. Möbius maintained that it was a reserve food supply, and recently (*Biol. Centralblatt*, 1888) Haseloff has experimented on *Mytilus edulis*, in which the structure is almost constantly present. He starved some individuals for a few days, and found that the style had disappeared. Others of the same starved lot were afterward fed with abundant food, and on examination were found to possess the style. Haseloff regards the style as a chemical modification of surplus food rather than a secretion.

Malacopoda—Peripatus comes in for several papers recently. Adam Sedgwick concludes his account of the development of the Cape species of the genus in the *Quarterly Journal of Microscopical Science*, Vol. XXVIII., part 3, and in part 4 of the same volume monographs the thirteen or fourteen known species of the genus. W. L. Sclater describes the early development of a South American species of the genus in part 3, and Miss Lilian Sheldon describes points in the anatomy of *P. capensis* and *P. novæ-zelandiæ* in part 4 of the same volume. In Vol. XII. of the *Zoologist*, S. A. Olliff has notes on Periaptus in New South Wales, and F. Jeffrey Bell calls attention to the fact that years ago Schmarda described a species of the genus (*P. quitensis*) from South America.

Crustacea.—Bouvier treats of the circulatory apparatus of the Decapod crabs in the *Bulletin de la Société Philomathique de Paris*, Vol. XII. His observations were made on the genera Maia, Stenorhynclus, Pagurus, Astacus, Palinurus, Portunus, etc.

Hoek describes a new parasitic Cirripede (*Sylon challengeri*) in Spencer Bates' report on the Macrura of the Challenger.

Cephalochorda.—Dr. E. Rhode (*Zool. Anzeiger*, XI.) describes the histology of the nervous system of Amphioxus. He finds it to resemble closely that of the Chætopod Sthenelais, in the presence of

colossal nerve fibres given off from regularly arranged giant ganglion cells. In both the supporting tissue is of ectodermal origin.

FISHES.—Messrs. Jenkins and Everman discovered a new species of the genus Chologaster this summer in the outlet to Lake Drummond, in the dismal swamp of Virginia. The discovery is especially interesting, as the genus is presumably the representative of the ancestors of the blind-fishes, Amblyopsis and Typhlichthys. Only their species of the genus — *C. cornutus*, *C. papilliferus* and *C. agassizii* were known before, and these were represented by but few specimens. Jenkins and Evermann were fortunate in obtaining a considerable amount of material of the new species.

MAMMALS.—Dr. Frederick Tuckerman describes the histological structure of the taste-organs of the bat, *Vespertilio subulatus*, in Vol. II. of the *Journal of Morphology*.

Some years ago the greenish color of certain of the sloths was attributed to the presence of an algæ upon the hair. Recently Madam Weber von Bosse has described two genera and three species of these parasitic algæ. The new genus Trichophilus is green, the other, Cyanoderma, with its two species is violet. From 150,000 to 200,000 individuals of these algæ may occur on a single hair.

ENTOMOLOGY.[1]

SCUDDER'S BUTTERFLIES OF NEW ENGLAND.[2]—The long-looked-for work by Mr. Scudder, on the butterflies of New England, is about to appear. We are in receipt of a prospectus which includes sample pages and plates. Judging from this the work will surpass in fulness of detail and magnificence of illustration anything of the kind yet published; and the scope of the work is an unusually broad one, including accounts of the structure of these insects in all stages of life, their variation, habits, manners, life-history, and their enemies; also frequent discussions of problems suggested by their study.

[1] This department is edited by Professor J. H. Comstock, Cornell University, Ithaca, N. Y., to whom communications, books for notice, etc., should be sent.

[2] The butterflies of the Eastern United States and Canada with special reference to New England, by Samuel Hubbard Scudder, Cambridge; published by the author, 1888. Twelve monthly parts, $5.00 per part, or $50.00 for the whole work if paid for before Jan. 1, 1889.

This work was at first intended to embrace only the butterflies known to occur in New England or its immediate confines; but it has been extended so as to include in its descriptions and histories some account of all the butterflies of North America, east of the Mississippi, excepting such as are found only in the unsettled parts of Canada, or south of Kentucky and Virginia.

Not only every species, but also every genus, tribe, sub-family, and family, are described and discussed with a fulness never before attempted, except in individual cases. The descriptions include in each instance not merely the perfect form, but when possible, the eggs, the caterpillar at birth and in the succeeding stages, and the chrysalis, together with the distribution, life-history, habits, and environments of the insects. A great accumulation of new facts and observations are embodied. Analytical tables applicable to every stage are used wherever possible.

Over seventy distinct excursuses, distributed throughout the work, discuss separately all the interesting problems which arise in the study of butterflies (whether of distribution, structure, history, or relation to the outer world), in themselves forming a complete treatise on the life of these insects. Judging by the fragment of the excursus devoted to dimorphism and polymorphism which is given in the prospectus, this part of the work will be of the highest interest to those who study entomology in a scholarly way, whatever their specialty.

Every page of this treatise bears evidence of the wonderful amount of pains-taking labor devoted to its preparation. For twenty years the author has been at work upon it; and for the last eight years it has received his undivided attention. No one else has brought to the study of this group of insects more scholarly attainments, nor has achieved such magnificient results. We trust that the work will receive the recognition that it deserves.

Vision of Caterpillars and Adult Insects.—Prof. F. Plateau continues his researches on the powers of vision by an investigation of caterpillars and of the frontal ocelli of adult insects.[1]

(1) He made a series of experiments and observations on the caterpillars of fifteen species of Lepidoptera, and obtained the following results: (a) The eyes of caterpillars have a more important rôle than that of simply distinguishing between light and darkness. They really see, though badly. (b) The distance of distinct vision is short, and usually about a centimetre. (c) At greater distances caterpillars can perceive large masses, but do not discern their nature. (d) They only perceive the movements of bodies within the limits of distinct vision. (e) Tactile hairs present on the anterior segments of many forms are of much sensory importance.

[1] Bull. Acad. R. Sci. Belg. xv. (1888), pp. 28–91.

(f) The antennæ are much used in testing the path and surrounding objects.

(2) In the next chapter Prof. Plateau discusses the function of the frontal ocelli of adult insects. He gives an historical summary of past researches, describes the manifold conditions of his own observations and experiments, submits tabulated results of his investigations of different forms, and formulates the following conclusions: (a) Diurnal winged insects, Hymenoptera, Diptera and Lepidoptera, when blinded by covering the entire eyes with black or by cutting all of the optic nerves, rise to a great height in the air when liberated. (b) When the compound eyes are suppressed, but the frontal ocelli left, in Hymenoptera, Odonata, and Diptera, the insects behave exactly as if the ocelli also had been suppressed. When freed, they rise vertically as before. In a chamber lighted from one side they behave as if they were totally blind. (c) But if the frontal ocelli be alone suppressed, the above insects behave as if they had lost nothing. (d) In diurnal insects equipped with compound eyes the ocelli count for almost nothing. They only afford the animals very feeble perceptions which they do not know how to use.

The author concludes his memoir with the following suggestions, which he describes as "plausible hypotheses," supported by a certain number of observed facts: (1) Diurnal insects, in which all of the eyes have been suppressed, still enjoy dermotoptic perceptions. (2) They are almost reduced to the same limitations if the ocelli are left at their disposal. (3) The dermotoptic perceptions are the primary cause of the ascending flight of liberated blinded insects. (4) The frontal ocelli serve neither for the perception of movements in adjacent objects, nor for the perception of light in relative obscure media. (5) The simple eyes, which the author has shown to function in an imperfect fashion in most Myriapods, in many Arachnids, and caterpillars, have entirely lost their utility in the great majority of insects equipped with compound eyes. (*Jour. Roy. Micr. Soc., June*, 1888.)

Life of Townend Glover.—A biographical sketch and an account of the writings of the late Towend Glover, the first United States Entomologist, written by Mr. Charles R. Dodge, has just been published by the Department of Agriculture at Washington.[1] Mr. Dodge was for a long time the assistant of Mr. Glover, and was one of his most intimate friends during the closing year of his life. He is, therefore, well fitted to perform this office and has done it in a very satisfactory manner. The work is illustrated by a portrait of Mr. Glover, copies of two of his earlier plates, and by several of his humorous caricatures. Numerous anecdotes are given

[1] U. S. Dep. of Agri., Div. of Ent., Bull. No. 18.

illustrating the peculiarities and eccentricities of this remarkable man. Following the biographical sketch is a chapter giving the history of Glover's great work entitled Illustrations of North American Entomology. There is also a short chapter on the Glover Museum, and a list of Mr. Glover's entomological writings; this includes sixty-four titles.

MONOGRAPHS OF NORTH AMERICAN SPIDERS.—We have received during the past month two monographs of North American Spiders. The larger of the two is of the family attidæ and is by George W. and Elizabeth G. Peckham. It is reprinted from the *Transactions of the Wisconsin Academy of Sciences, Art and Letters*, Vol. VII. It comprises 104 pages and is illustrated by six plates. An analytical key to the genera is given, and the specific descriptions are evidently very carefully prepared.

The smaller monograph is of the family Ciniflonidæ and is by J. H. Emerton. It is reprinted from the *Transactions of the Connecticut Academy*, Vol. VII. It comprises sixteen pages and is illustrated by three beautiful plates.

THE BEE-KEEPERS' GUIDE.—A new edition of this excellent manual of the apiary by Prof. A. J. Cook has just appeared. The work has been wholly re-written and revised, 150 pages and more than thirty illustrations being added. The greatest additions are in the chapters pertaining to the natural history of the honey-bee. We are glad to note also an improvement in the paper and press work. This is undoubtedly our best manual on the subject and it should be in the hands of every American bee-keeper.

ON PLATYPSYLLUS.—There appeared in the *Scientific American* Supplement of June 2, 1888, an important paper by Prof. Riley on the scientific relations of *Platypsyllus* as determined by the larva. The paper is based upon the study of larvæ collected for Prof. Riley by Mr. Lawrence Brunner in Nebraska. Three figures of the larvæ are given, and one of the adult. The conclusion drawn by the author is that this insect pertains to the order Coleoptera.

BIBLIOGRAPHY OF NORTH AMERICAN INSECTS.—Bulletin No. 19, of the Division of Entomology of the United States Department of Agriculture, is entitled An Enumeration of the published Synopses, Catalogues, and Lists of North American Insects. This is a very useful pamphlet, the scope of which is indicated by the title.

EMBRYOLOGY.[1]

On the Primary Segmentation of the Germ-bands of Insects.[2]—Prof. Veit Graber summarizes his important results on the embryology of insects as follows:—

1. The germ-band of insects is at first either discoidal (*Stenobothrus*, *Œcanthus*), or is oblong (*Hydrophilus*, *Lina*, etc.). The primitive discoidal germinal area corresponds principally to the (Urkopf) antennal segment, since the (Urrumpf) primitive body has at first very limited dimensions.

2. In most insects with an elongate germ-band, the primitive head-segment is also the first to be separated. An exception to this is found in *Lina*—if *Hydrophilus* is not taken into account—in which two transverse furrows appear simultaneously, forming three principal segments, which appear to correspond to the principal subdivisions of the insect body (head, thorax and abdomen).

3. The primitive body (Urrumpf) of the germ-bands of *Stenobothrus* and *Œcanthus* does not segment, as it has been assumed in the case in all insects hitherto, but before the permanent segments (metameres or microsomites) are established, the latter definitive segmentation is preceded by a subdivision into two and then three large segments (macrosomites).

4. Of these three primary segments (macrosomites) of the primitive body, the first corresponds to the sum of the jaw-bearing (gnathophorous) metameres—gnathal macrosomites—the second, the sum of the limb-bearing metameres—thoracic macrosomites—and finally the third to the abdomen—abdominal macrosomites.

5. In the process of the primary or macrosomitic segmentation of the primitive body there is no external segmentation, that is, transverse subdivision of the ectodermal plate, but a total segmentation of the inner (lower) layer, the hypo- (or ento-) blast.

6. The secondary or microsomitic segmentation of the primitve body (segmentation of the microsomites into metameres) does not proceed in *Stenobothrus* and *Lina* (and also in spiders according to Morin), as is generally assumed, from before backwards, but it first involves the middle or thoracic (Ursegment) macrosomite.

We may finally inquire as to the morphological significance of the primary subdivision into four or tetramerism of the germ-bands of *Stenobothrus* and *Œcanthus*.

[1] Edited by Prof. John A. Ryder, Univ. of Penna., Philadelphia.

[2] Über die primäre Segmentirung des Keimstreifs der Insekten. Morph. Jahrb. xiv. Hft. ii. 1888. Pp. 345–368, pls. xiv.–xv. Von V. Graber.

Since the two last primary segments (Ursegmente), namely, the thoracic and abdominal, correspond to the two sections of the body of the perfect insect, we may regard the primary segmentation as an anticipation of the later or tertiary segmentation. Against such a view two important facts are opposed. First, it is not to be forgotten that the primary segmentation does not conform to the tretiary, in that the head in the former does not constitute a primitive segment, but is divided into two sharply distinguished and heterogeneous sections, the primitive head segment (Urkopf) and the gnathophorous macrosomite.

Secondly, against the hypothesis alluded to, the whole progress of segmentation is opposed. If the macrosomites of the primitive body were to persist, as such, together with their later subdivisions (microsomites), as stem-unities of a higher order, the above view would be to some extent justified. The relation is, however, altogether a different one, in that between the few and unequally segmented stage on the one hand, and the similarly segmented end-stage on the other, a many and unequally segmented middle stage is intercalated, which bears scarcely a recognizable trace of the earlier segmentation, and out of which the trimerism of the end-stage is developed anew by the fusion of certain groups of metameres.

If the tetramerism of the segmented primary stage may not be readily explained by the not very sharply expressed trimerism of the end-stage, its cause must, without doubt, be sought in certain definite conditions of segmentation of the ancestors of insects. But, as I would especially point out, may the tetramerous germ-band stage here under consideration be compared with other adult similarly segmented arthropods without taking other matters into account, since, independently of the fact that our germ-band is not an independent (completed) living organism, there is wanting all support to a legitimate comparison of its macrosomites with other arthropods with few segments, such as the Nauplius, for example.

ARCHÆOLOGY AND ANTHROPOLOGY.[1]

(Continued from page 856.)

Dr. Brinton presented a human vertebra from Tampa Bay, Florida, found in the bog deposits of the quarternary geologic period. Its peculiarity was that the bony structure had passed and been replaced by a deposit of iron called limonite, so that it was an iron instead of a bone vertebra.

[1] This department is edited by Thomas Wilson, Esq., Smithsonian Institution, Washington, D. C.

Mr. Wilson said that the National Museum possessed the lower half of a human skull from the same neighborhood which had been treated in the same way. It was found associated more or less intimately with fragments of fossilized bones and teeth of the mastodon.

Prof. E. S. Morse, of Salem, Mass., read a paper, which he illustrated to the audience with a bow and arrow; showing a new system, the third in his series, of "Arrow Release."

Rev. W. M. Beauchamp displayed some Indian relics from central New York.

Prof. Joseph Jastrow, of the University of Wisconsin, read a most interesting paper on the "Psychology of Deceptions." He described deceptions practised upon the senses and said the foundation of legerdemain was to distract the attention by an unimportant operation from the critical moment wherein the vital change is made. He entered the domain of spiritualism but dealt with only that portion which was an evident deception, and had been exposed. The first general principle in these deceptions is that the medium performs to spectators in doubt as to the interpretation to be placed upon the scene which they witness, and are more or less ready to ascribe it to the supernatural. This mental attitude of the spectators is worth more to the medium than any factor in the performance. The difference between a spectator in this state of mind and one convinced of the fraudulent character of the manifestations and seeking to discover how the fraud is committed is very great. When the medium recognizes this condition of mind in the spectator the sitting will always be a blank. If the investigator is once convinced that he has evidence of the supernatural he soon sees it in every accident and incident of the performance; not only does he overlook natural physical explanations but the supernatural idea soon leads him to create marvels with sincerity. Thus, the believer, seeing a carelessly arranged drapery by a dim light thinks he recognizes in it the spirit of a dear friend or a well-known acquaintance. The same object is frequently recognized by different members of the circle as entirely different and wholly dissimilar persons. Little by little, through the neglect of observation, caution is abandoned, credulity takes possession of the spectator, and he is able to see impossibilities. Finally a fantastic explanation is considered more probable, the bounds of the normal are passed, and the believer having eyes sees not, and ears hears not, even the realities which happen before his face. If this seems impossible, turn back to the history of witchcraft.

In the afternoon the section met to hear Prof. Otis T. Mason, of the National Museum, Washington, D. C., deliver his lecture on "Women's Share in Primitive Industry." It was illustrated by photographs projected upon the screen by the lantern, of woman in

her different spheres of industry through savagery, barbarism, civilization, and into the heavens where she is deified and appears as a goddess.

Thomas Wilson, Esq., of the Smithsonian Institution, gave the result of his investigations as to the geographic distribution in the United States of man during the paleolithic period. An abstract of his remarks will appear at some future time in the NATURALIST.

It was now after three o'clock in the afternoon of the last day of the meeting when Rev. S. D. Peet, of the *American Antiquarian*, commenced his observations upon Effigy Mounds, The Clan System among the Mound Builders, Did the Cherokees build in the Scioto Valley? and The Mounds in the Mississippi Bottoms used as Refuges in times of High Water. These will probably appear in the *Antiquarian*.

The closing general session was held in the auditorium Tuesday evening.

Prof. T. E. Mendenhall, of Terre Haute, Ind., was chosen President for the next meeting, which is to be held in 1889 at Toronto, Canada.

The Vice-President chosen for section H was Col. Garrick Mallery, of the Bureau of Ethnology, Washington, and for Secretary, Rev. W. M. Beauchamp, of Baldwinsville, New York.

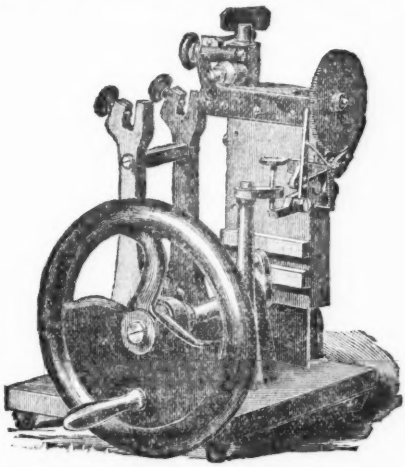
The committee appointed at last general meeting to secure from Congress the abolition of the customs duties on scientific books and apparatus, made a lengthy report in favor thereof.

The committee on the preservation of archæologic monuments on public lands reported in favor of the following as proper subjects for preservation: Chaco cañon from the forks of Escavoda cañon for a distance of eight miles up, also one mile back from the brink of the cañon walls on each side so as to include many interesting structures. Cañon de Chelly, Cañon del Muerto, Walnut cañon, the ruin on Fossil creek on east branch of the Rio Verde and about fifteen miles south of Camp Verde military reservation, the ruin in Mancos cañon, the round towers in the flat valleys of the lower Mancos, the cave lodges in the cinder cone about eight miles east of Flagstaff, A. T. Besides these groups of ruins and dwellings there are isolated remains in the territories of New Mexico, Arizona and Utah numbering over forty, which demand preservation. The Pueblos, which are not in treaty reservations or grants, and the old Mandan and Arickaree village on the Fort Berthold Indian reservation, D. T., to be preserved when they shall cease to be inhabited by Indians. And the committee was continued.

After the usual resolutions and speeches of thanks and acknowledgements to the local committee and to the citizens of Cleveland, the meeting adjourned *sine die*.

MICROSCOPY.[1]

MINOT'S AUTOMATIC MICROTOME.—The principle of this Microtome is to obtain sections by moving the object to be cut in a vertical plane past the knife which is held in a fixed position. The knife is clamped by two screws in jaws at the top of two upright pillars to be seen in the figure. The object to be cut is imbedded in paraffine and stuck on to a circular brass plate which faces the knife, when the plate is in position. This plate has the motion in three directions, and may be revolved around its own centre, so that the position of the object may be adjusted as desired. The well-known construction, used on the Schanze Machines, has been adopted to secure the necessary play of movement for the plate,



carrying the paraffine. This construction was selected on account of its simplicity and convenience, and the great firmness with which the plate may be clamped. The object holder rests on a horizontal plate which may be fed towards the knife by a micrometer screw, the head of which is a toothed wheel. *Each tooth equals* $\frac{1}{300}$ *mm. forward movement.* The whole of this complete object-carrier is fastened to an upright slide. The slide is worked up and down by a crank, as seen in the cut, and the crank is moved by turning a heavy iron wheel.

[1] Edited by C. O. Whitman, Director of the Lake Laboratory, Milwaukee, Wis.

When the wheel is revolved, the crank is turned, and the upright slide rises and falls in a vertical plane, and of course the object-carrier, with its micrometer screw, rises and falls with it. As the carrier rises a lever connected with a pawl strikes against a screw on a separate pillar; the pawl catches in the toothed wheel-head of the micrometer screw and so turns it, and moves the paraffine towards the knife. As the carrier descends a section is cut off, when it is near the top of its upward excursion, the micrometer screw is turned by the pawl, and the next descent produces another section. By simply turning the screw against which the pawl lever strikes, the number of teeth caught by the pawl, and therefore the thickness of the sections may be varied from 1-300 to 1.33 of a millimeter.

This microtome has been devised to avoid the obvious inconveniences attaching to the rocking and other automatic microtomes.

Since the first lot of these microtomes were placed in the market, some important improvements have been made, among which may be mentioned the strengthening of the upright slide in which the carrier moves. This improvement secures regularity and precision in the movement of the object, and renders the microtome one of the best for paraffine-cutting now in the market. This microtome, with one knife in case, is supplied by the Educational Supply Company, 6 Hamilton Place, Boston.

THE EYES OF SCORPIONS.[1]—In the median eyes, by careful dissection, the soft part may be separated from the lens and cuticula, and cut without the interference of these hard structures. The separation is best accomplished after the tissues have been hardened. This method of dissection cannot be applied to the lateral eyes, for they are almost completely surrounded by chitine. In these eyes the best results were obtained by trimming off the chitine around the eyes, and cutting the retina and the lens after the removal of as much chitine as possible.

The pigment is so abundant and so dense that even the thinnest sections cannot be studied to advantage until they have been depigmented. For this purpose I know of only two classes of successful reagents, acids and strong alkalis. Grenacher has generally employed the first, Graber the second.

Of the acid reagents strong solutions are required. Lankester and Bourne employed 5 or 10 per cent. solutions of nitric acid. In the eyes which I have studied, this mixture did not remove the pigment, even after the lapse of a week; and I was forced to use stronger and stronger grades, till 50 per cent. was reached. This mixture gives fair results, but must be made and used with caution. *A given volume of acid should be poured slowly into an*

[1] G. H. Parker, "The Eyes in Scorpions." Bull. Mus. Comp. Zool., vol. xiii., No. 6, pp. 174-177. Dec., 1887.

equal measure of alcohol, never the reverse, and the mixture should be kept cool, otherwise the acid may attack the alcohol. In such an event the solution is rendered worthless, and, should the specimens be in it at the time, the heat generated by the reaction gives the acid such additional dissolving power that the sections are at once destroyed. A more efficient acid reagent is a mixture of equal parts hydrochloric and nitric acids. A 35 per cent. solution of this mixture in strong alcohol gives better results than the pure nitric acid at 50 per cent., and does not so readily attack the alcohol.

Of the alkalis, weak ammonia, sodic hydrate, and potassic hydrate are most serviceable. The solids are to be preferred to the ammonia, since from them solutions of a definite strength can more easily be made. An aqueous solution of $\frac{1}{3}$ or $\frac{1}{4}$ per cent. potassic hydrate has given the most satisfactory results.

The method of using the depigmenting fluid is as follows. Unstained material is cut in paraffine; the ribbons are mounted on a slide with Schällibaum's fixative; when the sections are fixed, the paraffine is removed with turpentine; the slide with the sections is then successively washed with alcohol of 98 per cent., 90 per cent., 70 per cent., and so on, till a grade homogeneous with the depigmenting fluid is reached. Into a shallow white dish filled with the depigmenting fluid the slide is now gently lowered. In a *few seconds* the pigment, dissolving, will be seen as a reddish cloud. The process is usually completed in less than a minute, and the slide is promptly transferred to a dish of clean water or alcohol and there gently rinsed. The sections are next stained by exposure to the dye in a shallow dish. After being sufficiently stained, they may be washed and mounted in glycerine, or, after the proper steps in dehydrating and clarifying, mounted in benzol-balsam or other mounting medium.

The dyes which have been found the most serviceable are some of the carmines and hæmatoxylin. The aniline dyes have almost invariably given poor results. For general purposes Grenacher's alcoholic borax-carmine is excellent. In both embryonic and adult material Czoker's alum-cochineal gave fine nuclear outlines. In the adult eyes, the rhabdomes and the cell boundaries were most distinctly shown by Kleinenberg's hæmatoxylin. A very faint coloration with this dye gave the best results for nerve-fibres.

For the isolation of the retinal elements two maceration fluids were used. A weak solution of chromic acid, as employed by Patten, gave good results; but since the mycelium of a fungus is often developed in very dilute solutions of this reagent, it can be used only when it is carefully watched and its results are controlled by another method. It was employed in the following manner. The retina, after the removal of the lens and surrounding tissue, was placed for five or ten minutes in a $\frac{1}{5}$ per cent. solution. After this treatment,

which slightly hardened the tissues, the first solution was replaced by a second of $\frac{1}{50}$ per cent. In this the retina remained for three or four days, at the end of which time the retinal cells were easily separable. The most satisfactory method of isolating the cells is to place on a slide in dilute glycerine a small portion of the macerated retina, and, having protected it with a cover-glass raised on wax feet, to gently tap the cover-glass till the cells are separated. One part of 0.2 per cent. solution of acetic acid in sea-water mixed with an equal volume of 0.04 per cent. osmic acid in sea-water, although only partially successful as a maceration fluid for the retina in scorpions, is a reliable check for the results obtained from chromic acid.

After the cells have been isolated, the abundance of pigment which they contain so obscures their contents that scarcely more than their outlines can be studied. The removal of the pigment is on the whole more successfully accomplished before than after isolation. For this process, as for simple isolation, the retina should be subjected to the action of $\frac{1}{5}$ per cent. chromic acid for five or ten minutes, and then transferred to a solution of $\frac{1}{3}$ per cent. potassic hydrate. In this the pigment dissolves, forming a reddish cloud. After about a minute the retina should be removed to distilled water, rinsed, and transferred to Grenacher's alcoholic borax-carmine. This reagent performs both the office of a maceration fluid and a dye. In from twelve to twenty-four hours the retinal cells can be isolated, and present in different regions of the retina three principal conditions. First, those from the exterior of the retina are seriously altered by the continued action of the potash; second, those from the centre of the retina remain almost unchanged, still retaining most of their pigment; third, those from an intermediate position, without being otherwise much altered, lose most of their pigment. It is from these last that the best results were obtained.

SCIENTIFIC NEWS.

—The President has directed Maj. George M. Sternburg, Surgeon U. S. A., to proceed to Decatur, Ala., and to such other points as he may deem necessary to continue his scientific investigations of the yellow fever.

—Among the works announced for immediate publication are: "Essays," by Prof. Huxley; "Wild Beasts and their Ways," by Sir Samuel Baker; "On Truth—a Fundamental Inquiry touching upon Various Popular and Scientific Beliefs," by Prof. St. George Mivart; "Mental Evolution in Man," by Dr. George J. Romanes; "Nature and Man," by the late W. B. Carpenter; "A Personal Narrative of the Euphrates Expedition," by Rev. W. F. Ainsworth.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

BIOLOGICAL SOCIETY OF WASHINGTON.—*October 20th.*—The following communications were read: Mr. L. O. Howard, "An Apparatus for the Study of Underground Insects and Plant-Roots;" Professor Lester F. Ward, "The King Devil;" Mr. J. B. Smith, "Some Remarks on Sexual Characters in *Lachnosterna;*" Dr. Theo. Gill, "The Families of Fishes."

INTERNATIONAL CONGRESS OF GEOLOGISTS.—This body met in London on Monday, September 17th, and closed its sessions Saturday, September 22d. After its close, five excursions occupied several days.

September 17th, Monday evening.—Address by Professor Prestwich, followed by reception by Professor and Mrs. Prestwich.

September 18th, Tuesday morning.—Regular opening. Reports of Committee upon Nomenclature. Discussion of Nomenclature of Cambrian and Silurian systems especially, and as to the value of the proposed *Orthrocene*. (See Prestwich's Address, page 9.)

September 19th, Wednesday morning.—Discussion of Crystalline Schists. Afternoon, reception by Professor Flower in Natural History Museum. Evening, reception by Director Geikie in School of Mines, Jermyn Street.

September 20th, Thursday.—Discussion of the Nomenclature of

the Geological Map of Europe. In the afternoon, excursions to Windsor and to Eton, by invitation of the Professors of Eton College; to Kew, and to Erith, Crayford, etc.

September 21st, Friday.—In the afternoon, reception at the rooms of the Geological Society, Burlington House, by the President, Dr. W. T. Blanford.

The results of the congress are thus summed up by the President, Professor Prestwich:—

He said: We approach the end of the congress, and we can now congratulate ourselves upon the results obtained. The first sitting was devoted to the discussion on the divisions of the Cambrian and Silurian systems, and although no vote has been taken, the opinions expressed have demonstrated that all are in accord for retaining the three groups or zones of Barrande and Murchison. But the necessity is not seen of making, as some members proposed, the intermediate zone a separate system. Thus the *status quo* of the Upper and Lower Silurian for the beds as far as the Tremadoc, and of the Cambrian for the group below, will not be affected. Two sittings have been devoted to the discussion on the origin of the crystalline schists by hydrothermal chemical action or by movements, for each of which causes powerful arguments have been advanced. The congress had received and printed in advance memoirs by eminent geologists, which will be valuable documents in the solution of this important problem. Another sitting took cognizance of the connection between the Tertiary and the Quaternary, the result of which is that, although opinions are divided, the majority of members approve of retaining the term Quaternary. Although in these cases votes had not been taken, the discussions had a great interest in the demonstration of the ideas which predominated among the most distinguished geologists. According to the resolutions adopted by the Committee on Voting, it will be easier in the future sessions to arrive at more positive conclusions. The reports which the Committee of Nomenclature has received from the national committees, and which are printed, are of great importance, and will serve as bases for a more settled classification. It is to be regretted also that the great palæontological work of all the known fossils is about to be abandoned for the present, by reason of the great expenses which it involves. One of the most important objects of the congress has been brought to a conclusion—the unification of colors and shadings in maps, and the Committee on the Geological Map of Europe announce to us that the publication of this fine map will not be delayed.

Some six hundred members were registered, of whom one hundred and forty-two were from countries other than Great Britain. The Americans present were Messrs. Dall, Fraser, Gilbert, Marsh,

Newberry, Osborn, Walcott, Williams, of Cornell, and Williams, of Johns Hopkins.

Invitations to hold the next meeting were received from Philadelphia, New York, and Washington. Philadelphia was chosen.

AMERICAN PHILOSOPHICAL SOCIETY.—*January 20, 1888.*—Prof. Cope presented for publication the following papers:

(1) "Synopsis of the Vertebrate Fauna of the Puerco Epoch of North America."

(2) "Lemurine Reversion in Human Dentition."

(3) "The Shoulder-girdle and Limbs of Eryops."

February 3.—Dr. Horn exhibited seven species of Pleocoma from California, of which three were new, and supported the views of the late Dr. Le Conte of the position of this genus, which he insisted was a Laparostict, and not a Pleurostict Lamellicorn.

February 17.—Prof. Cope presented for publication papers upon "The Dicotylinæ of the John Day Miocene of North America," and upon "The Mechanical Origin of the Dentition of the Amblypoda."

March 2.—Prof. T. B. Stowell presented papers on "The Hypoglossal, Accessory and Glosso-pharyngeal Nerves of the Domestic Cat;" and Mr. F. Jordan an article on "The Aboriginal Pottery of the Middle Atlantic States."

March 16.—Dr. Frazer made a communication respecting the geology of the eastern part of Cuba, reporting the probable occurrence of a large part of the Archæan rocks which lie between the Lower Laurentian and the Palæozoic. Miss H. C. de S. Abbott made some remarks upon the occurrence of a "Series of New Crystalline Compounds in Higher Plants."

Mr. H. Phillips, Jr., presented a first contribution to the "Folk-lore of Philadelphia and its Vicinity;" and Dr. O. Meyer a paper on "The Miocene Invertebrates from Virginia." Mr. Phillips also reported on the "Langue Internationale" of Dr. Samenhof, of Moscow.

April 6.—Mr. Law presented a paper on "Gildas and Early English History," and Prof. E. J. Houston made an oral communication upon "Death by the Electric Current," in which he held that the fatality largely depended upon the part of the body brought in contact with the wires. Prof. Houston also reported favorably upon the Paillard Palladium alloys in watches as a preservative against the effects of magnetism.

April 20.—Prof. Houston presented a paper upon "Some Possible Methods for the Preparation of Gramophone and Telephone Records." Mr. Phillips exhibited a specimen of Physa found from the pipes of the drinking supply, and this was followed by a discussion of the water-supply of cities.

May 4.—The Magellanic medal was presented to Prof. L. M.

Haupt for his paper upon "The Physical Phenomena of Harbor Entrances."

The following papers were presented: "On the Classification and Nomenclature of the Metalline Minerals," by Dr. T. Sterry Hunt; "On the Ear-bones of the Permian Batrachia," by Prof. E. D. Cope; and on "Two New Species of Ophidia from Mexico," by Dr. A. Dugés.

September 7.—The following papers were presented:

"Ibrahim Nukim, ein Guslarenlied der Herzegovina," by Dr. E. S. Krauss (Vienna); "Action of the Gas from As_2O and HNO upon m-Oxybenzoic Acid," by Prof. E. A. Smith; on the "Cretaceous and Tertiary of the Sergipe Alagias Basin of Brazil," by Prof. J. C. Branner.

September 21.—Dr. H. A. Hare presented for the Transactions a paper on the "Diseases of the Mediastinum."

October 5.—Dr. D. G. Brinton read a paper on the "Language of Palæolithic Man."